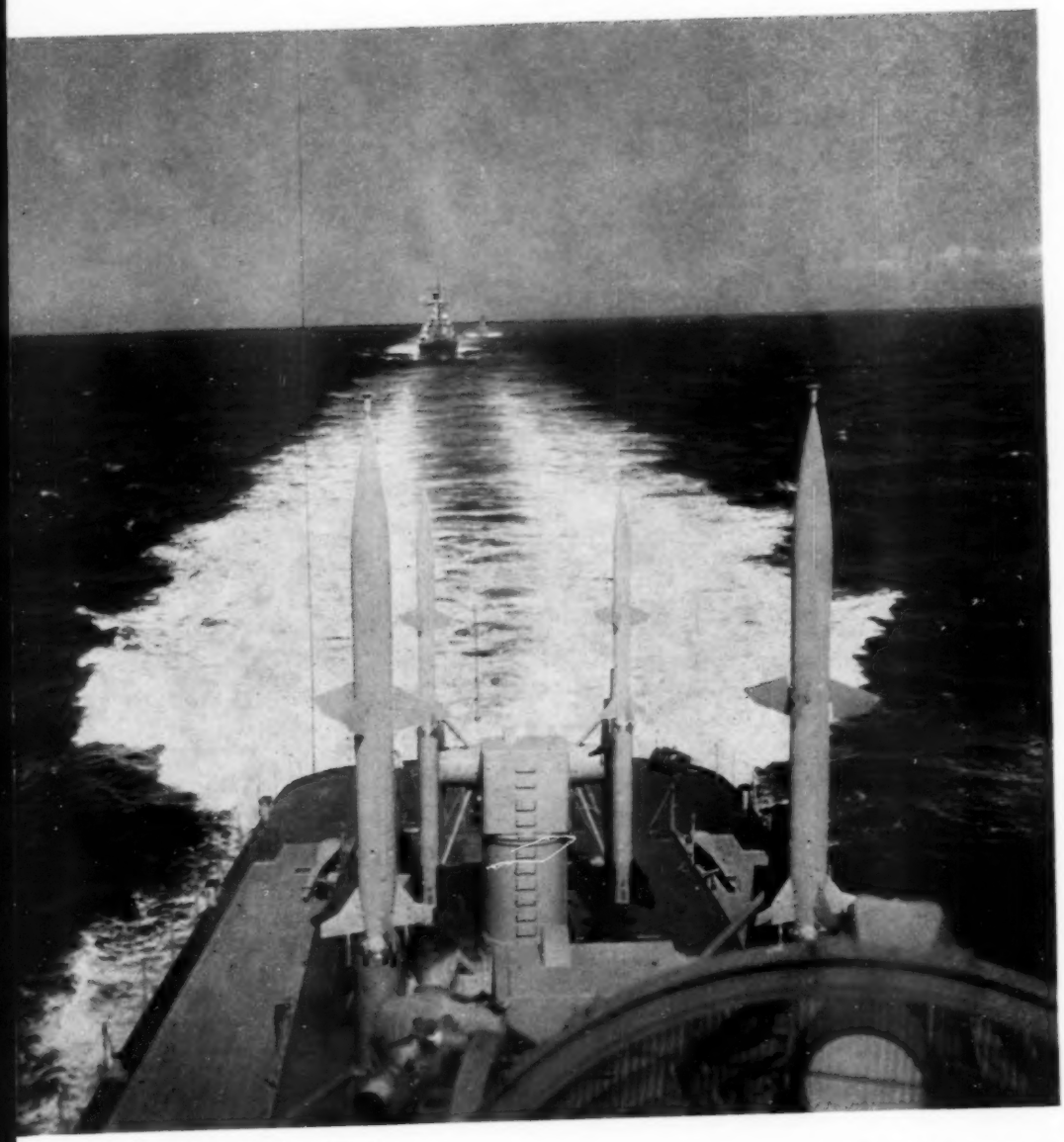
ORDNANCE

LAND · SEA · AIR



New Naval Firepower

NOVEMBER-DECEMBER 1956

Wright cranes keep engines flying through world's largest line-maintenance hangar

...with the help of 480 TIMKEN® bearings

24 motor-driven Wright cranes like the one shown keep engines winging from station to station in the world's largest line-maintenance hangar at Miami. And keeping the cranes on the go are 480 Timken® tapered roller bearings on the bridge wheels and trolley wheels.

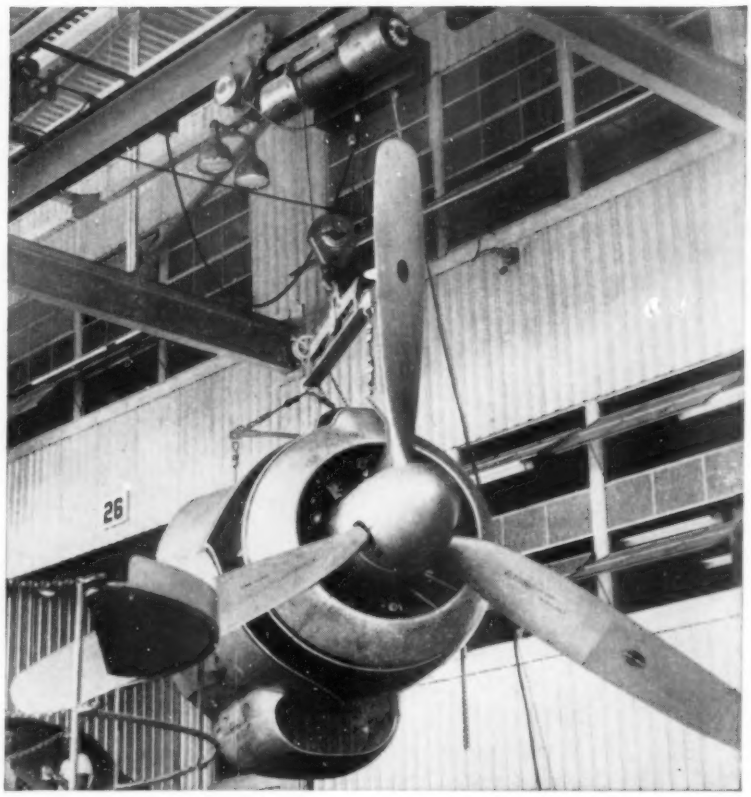
Timken bearings take both the radial loads imposed by the weight of the engines and the thrust loads set up by the pendulum motion of crane operation. The tapered design of Timken bearings lets them take radial and thrust loads in any combination. And full line contact between rollers and races gives these bearings extra load-carrying capacity. Downtime is cut, cranes are kept on the go.

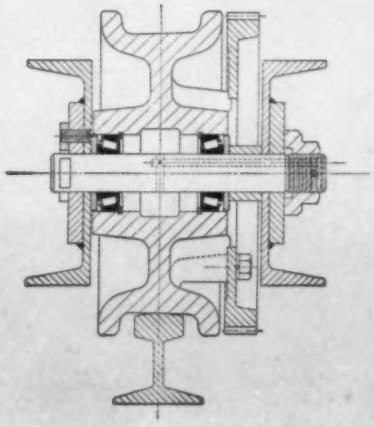
Friction is virtually eliminated with Timken bearings. They're designed by geometric law to have true rolling motion—precision manufactured to live up to their design. Cranes roll smoothly with a minimum of wear and maintenance. And to take the shock loads often encountered, rollers and races of Timken bearings are case-carburized to give them wear-resistant surfaces over tough, shock-resistant cores.

Be sure you specify Timken bearings when you build or buy a machine. To give you the *finest* roller bearings, we even make our own fine alloy steel. We're America's only bearing manufacturer that does.

Look for the trade-mark "Timken" on every bearing. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.





How the **WRIGHT HOIST DIVISION** of American Chain and Cable Co. mounts Timken tapered roller bearings on the truck wheels of its cranes to take the loads, keep them on the go.

TIMKEN *TAPERED ROLLER BEARINGS ROLL THE LOAD*

TRADE-MARK REG. U. S. PAT. OFF.

ORDNANCE
LAND · SEA · AIR

The Magazine of Scientific and Industrial Preparedness Now in Its 37th Year

VOL. XLI NOVEMBER-DECEMBER 1956 NO. 219

The Cover.—*Four Navy Terrier antiaircraft guided missiles are shown poised in their automatic launchers aboard the cruiser* BOSTON (CAG-1) *while the* NORTHAMPTON (CLC-1) *and the* FORREST SHERMAN (DD-931) *bring up the rear.*

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FEATURES

New Naval Firepower . . . . . Front Cover
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Rear Adm. John H. Sides . . . . . Frontispiece
Navy photo of the Deputy Special Assistant to the Secretary of Defense

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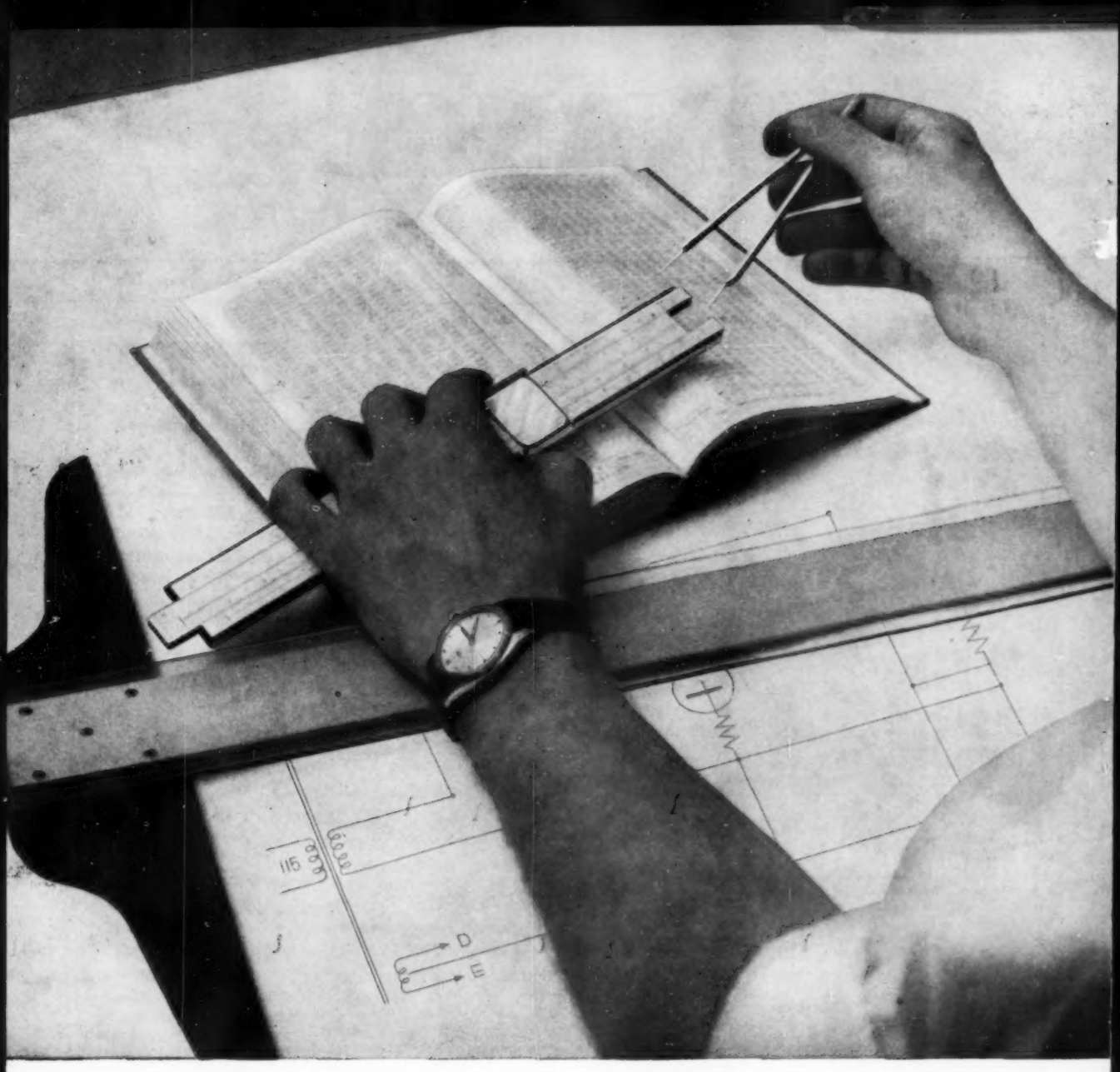

What's most important in this picture?

Not the slide rule, though it's helpful. Nor the divider. Nor the logarithm table. It's the human hand, of course, because it is motivated by the long, strong arm of human intelligence. It belongs to the career engineer dedicated in his service to the Department of Defense.

His mind and his hand shorten the coupling between a need urgently expressed by the military and its translation by industry into reliable electronic equipment. His experience contributes invaluable help at a critical stage in developing great new things in aviation electronics.

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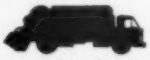

Garbage and trash collection

Concrete mixers and similar industrial applications

Materials handling machinery

Many stationary power plants and oil field applications

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Courtesy of Ingersoll Kalamazoo Division, Borg-Warner Corporation, Design Agent and Builder of LVT's.

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New mass-produced return bends help you solve design problems where space is limited

Designers face the unending task of compressing vital equipment into progressively smaller "packages." While helping solve these design problems, Bundy® has established new minimum standards for the mass production of return bends with fittings attached, in tubing from 3/16" to 5/8" O.D.

For example, designing hydraulic actuators for automotive and other uses involves bending tubing to minimum radii, because of severe space limitations. At the request of leading fabricators, Bundy developed the minimum mass-production standards tabulated at right. For special problems, where space is more important than speed of production, Bundyweld® can be fabricated to even closer tolerances.

Bundyweld Tubing takes such fabrication easily because it's the only tubing double-walled from a single metal strip, copper-bonded through 360° of wall contact. The result: stronger, vibration-resistant tubing with high bursting strength and high thermal conductivity. No wonder Bundyweld is the accepted standard of the refrigeration and automotive industries: *it is used in 95% of today's cars, in an average of 20 applications each.*

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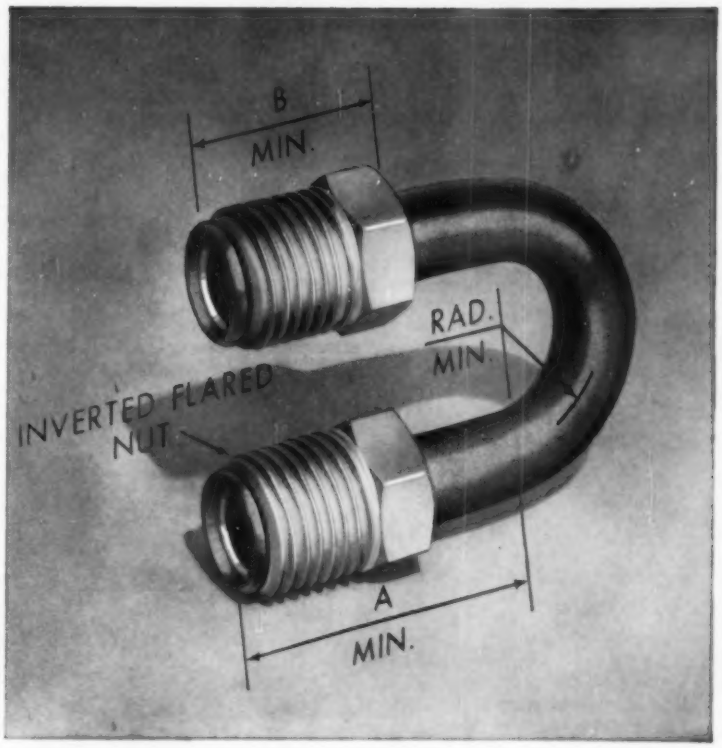
DETROIT 14, MICHIGAN



TUBE O.D.	3/16	1/4	5/16	3/8	7/16	1/2	5/8
RAD.-MIN.	5/16	3/8	5/8	3/4	7/8	1	1 1/2
A-MIN.	3/4	7/8	1	1 1/16	1 1/8	1 1/4	1 3/8
B-MIN.	5/8	5/8	1 1/16	2 3/32	3/4	1 3/16	7/8
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helping hands . . . united yet diversified

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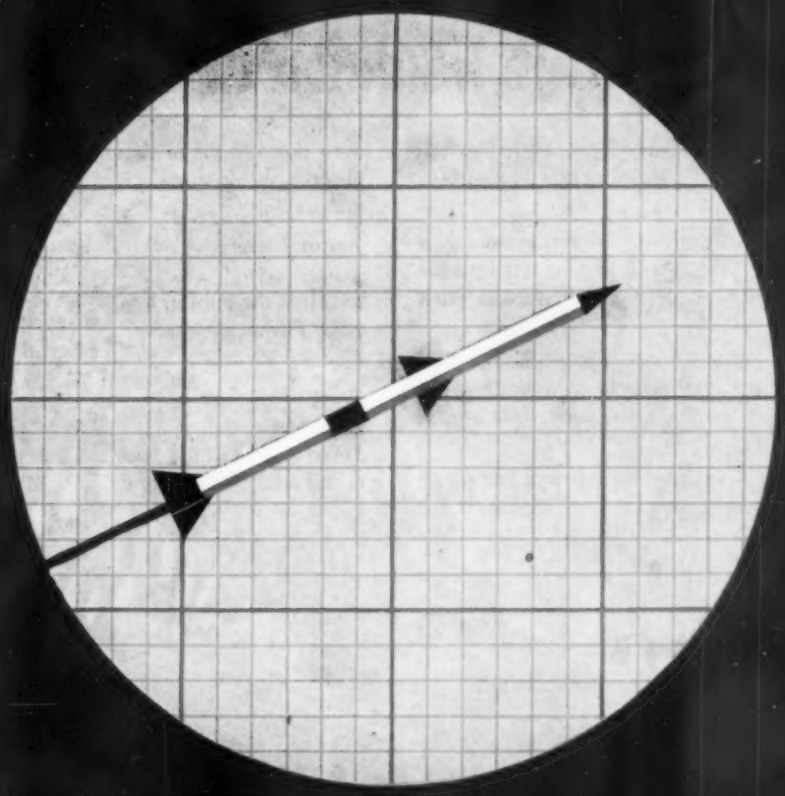

BALLISTIC MISSILES

on target a continent away through Burroughs computation

For some time, Burroughs has been participating in the U. S. Air Force Ballistic Missiles program in the field of guidance. This program consists of two intercontinental ballistic missiles: *Atlas* and *Titan*, plus an intermediate range missile, *Thor*.

Here's more proof that in its specialized areas of computation—instrumentation, control systems and data processing—Burroughs has what it takes to shoulder the overall responsibility for defense projects from beginning to end: (1) from research to development; (2) engineering and tooling; (3) production, testing, field service and training.

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And this headline-making drive does more than fulfill a driver's dream as he puts this International Harvester 24-ton Model 95 Payhauler through its paces.

It speeds trips and job-cycle times. There's no break in the power flow as the driver flicks a lever to switch speed ranges with terrain changes. There's no clutch-pedal pushing, no gearshift-guesswork.

Allison TORQMATIC DRIVE holds maintenance and repair costs down to the minimum. The TORQMATIC converter absorbs shock loads, prevents harmful engine lugging and stalling.

Another exclusive feature of this TORQMATIC DRIVE greatly extends service-brake life, makes driving safer, too. It is the built-in hydraulic retarder which gives this hefty Payhauler a second braking system that saves regular service brakes for full stops or snubbing on curves.

Want to know more about this great new Allison Model CBT-5640 FourSpeed TORQMATIC DRIVE? Write Allison Division of General Motors, Box 894W, Indianapolis 6, Indiana.

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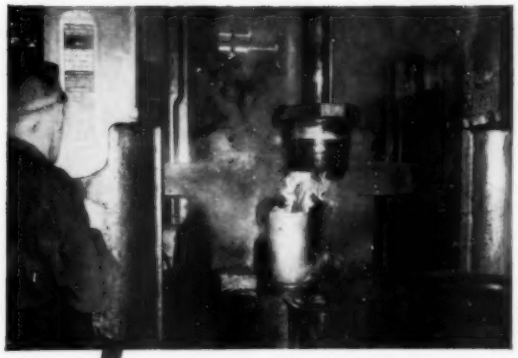

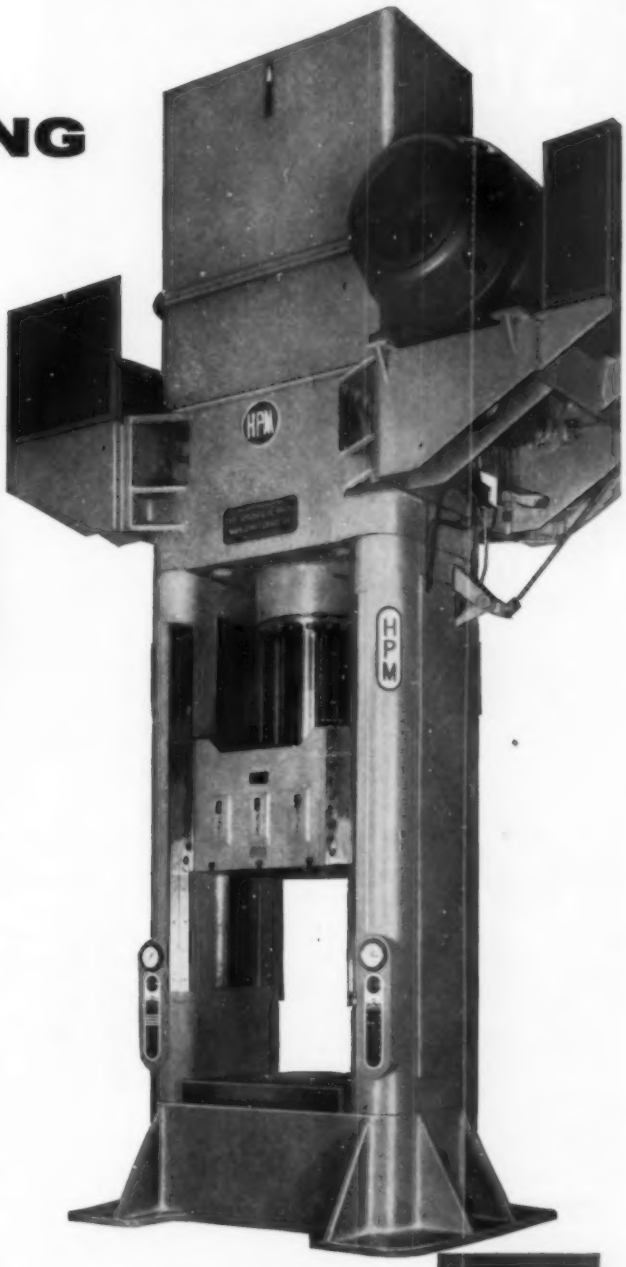

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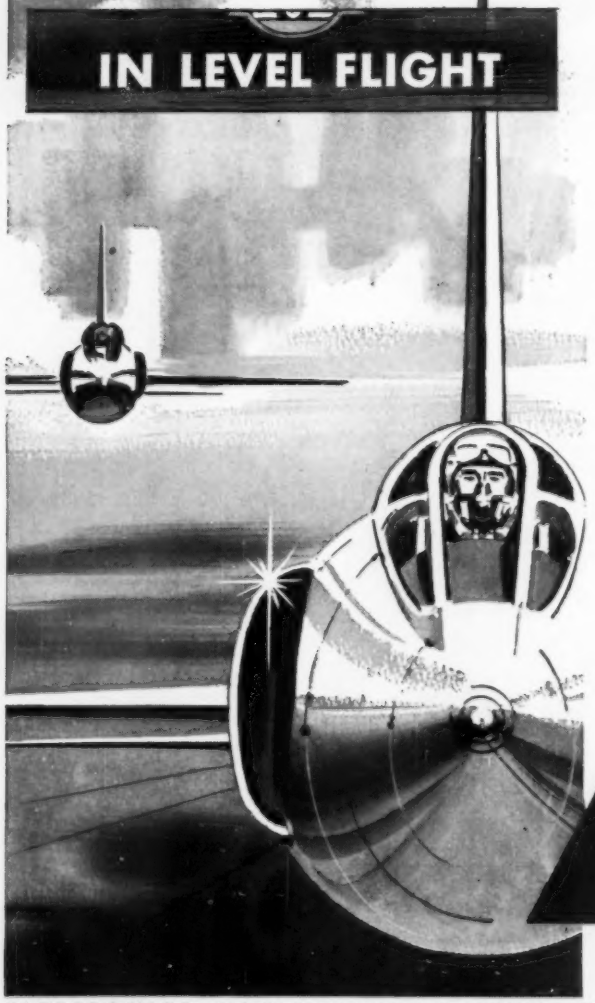

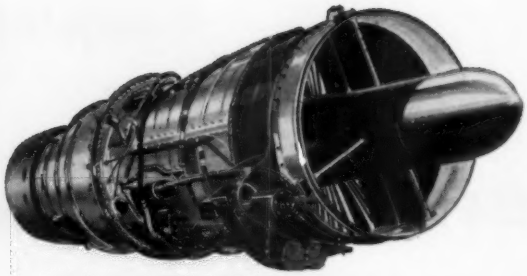

J65 JET

WITH AFTERBURNER

Supersonic speed in a dive is one thing. But in level flight it's quite another. It means that a fighter like the Grumman F11F-1 "Tiger" has the power — for acceleration and climb — and the maneuverability that help a fighter outperform the enemy in any situation.

The Curtiss-Wright J65 Jet Engine with afterburner is designed for top performance in jet aircraft of near-sonic and supersonic speeds. It provides 7800 pounds of thrust without afterburner . . . and a big blast of extra power with afterburner cut in. But equally important, the J65 is a tested and proven jet engine, with an operational backlog of hundreds of thousands of hours of day-in, day-out service on leading military aircraft for the U. S. and NATO nations throughout the free world. It holds many world's records for both speed and endurance. In addition to the F11F-1 "Tiger," advanced Navy and USAF aircraft such as the Douglas A4D "Skyhawk," Republic F84F "Thunderstreak," RF84F "Thunderflash," North American FJ-3 and FJ-4 "Furies," and other high performance, classified aircraft are powered by various models of this outstanding Curtiss-Wright powerplant.

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Through Production, Research and Development

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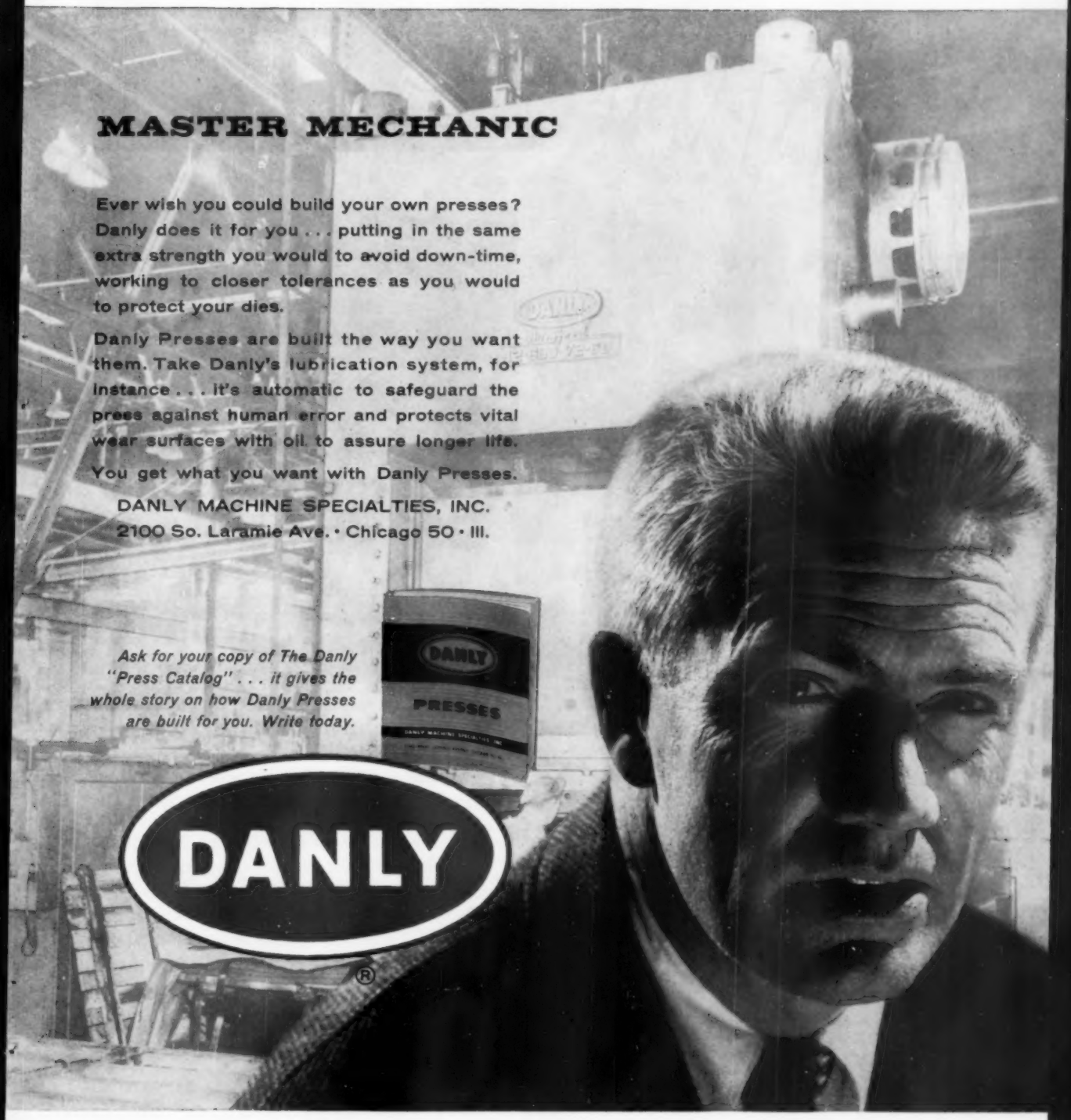

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In contrast to "push-to-talk" radio, this link handles communications with far greater speed, reliability and privacy. Portable and rugged, with a range up to 50 miles, the unit can be set up in minutes, has its own AC generator.

Now operating for telephone companies, the TCR-12 offers reliable, low-cost communications to the Armed Forces, civilian defense, pipe lines, railroads and power utilities. This new concept in communications is further evidence of Raytheon's *"Excellence in Electronics."*

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7305

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ANN ARBOR, MICHIGAN

U. S. Air Force Photo

An Air Force cargo plane delivers vital Air Force supplies to an overseas base.

AIR MATERIEL COMMAND IS GLOBAL LINK BETWEEN RESEARCH AND COMBAT UNITS

Supplying the Air Force with the right equipment, at the right place at the right time is the mission of Air Materiel Command. Its procurement, supply and maintenance operations fill the area between research and development on one side and combat units on the other. It is the largest business in the country.

Because our Air Force is operating in all quarters of the earth, AMC is a globe-circling operation with its headquarters centered at Wright-Patterson AFB near Dayton, Ohio.

The vital logistic mission for the Air Force involves billions of dollars in procurement, thousands of airplanes, and more than a million different kinds of supply items. Organizationally, AMC includes fourteen air materiel areas, or major area depots, located in the United States, Europe, North Africa, and the Pacific. Geographically, air materiel operations extend throughout the free world.

Working with weapons systems contractors in private industry, AMC procures the equipment which has been developed and tested by the Air Research and Development Command, and distributes the equipment to combat units as needed. The never ending objective of the Air Materiel Command is to maintain an instant combat readiness, logistic-wise, in this era of super speeds and super weapons to support Air Force operations at any point on the globe. The philosophy of Air Materiel Command is that such readiness must be characterized by the closest interrelations of combat and logistic elements, by speed, flexibility, mobility and economy.

This is one of a series of ads on the technical activities of the Department of Defense.

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DIVISION OF SPERRY RAND CORPORATION
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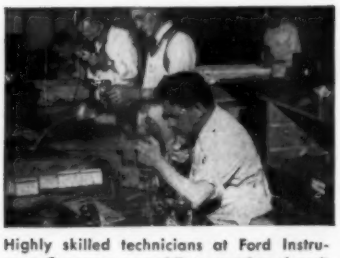

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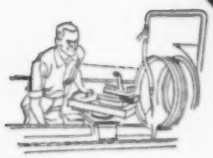

They are rings that offer additional manufacturing savings. Since the rings are closer to the desired finished cross section, it is less expensive to machine them to a final dimension. Oh yes, Amweld will machine them for you.

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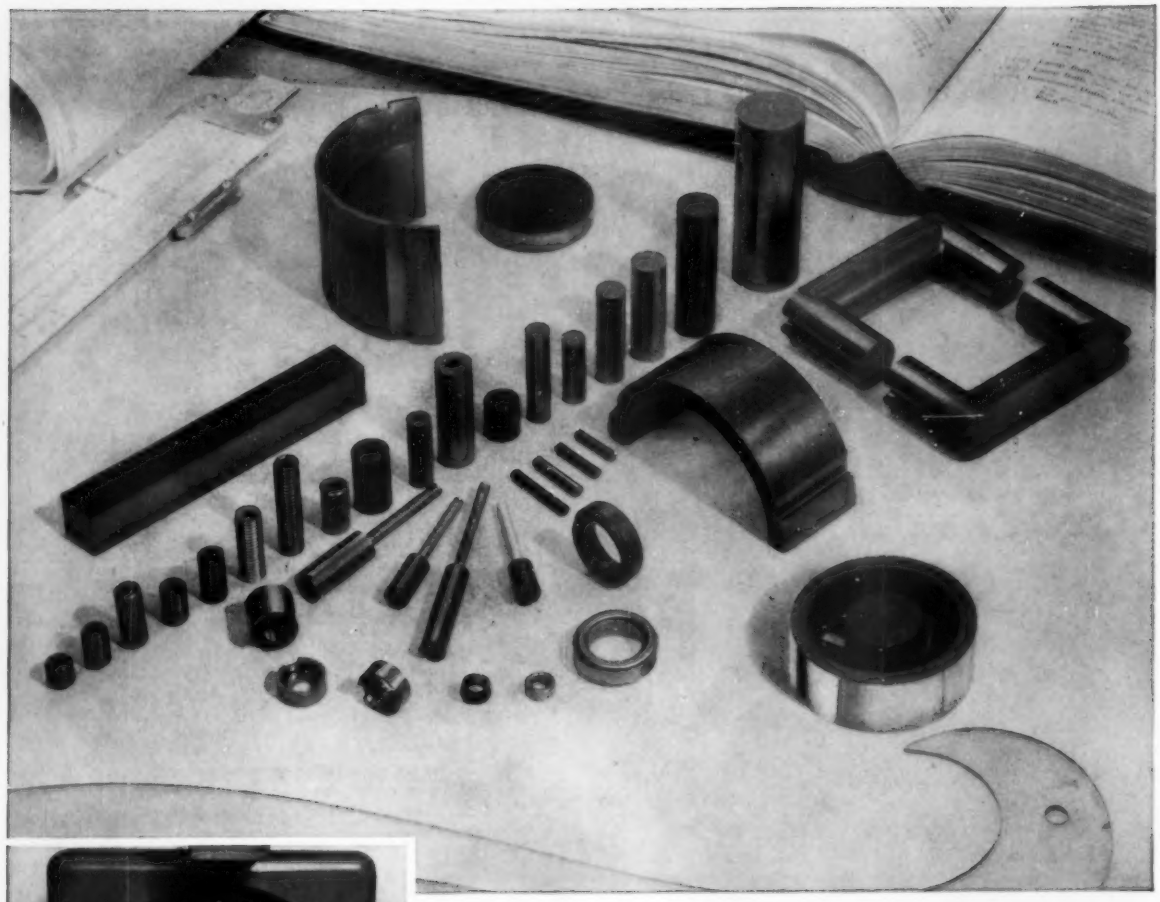

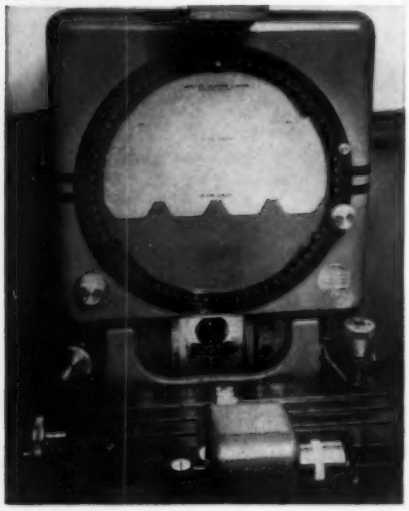

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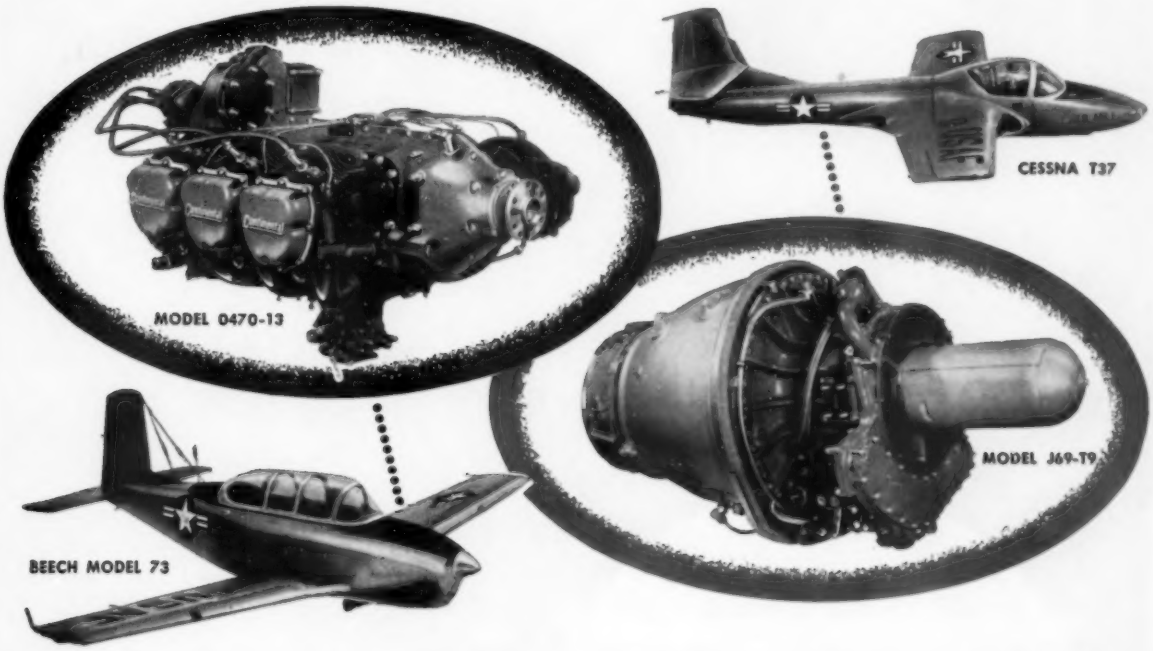

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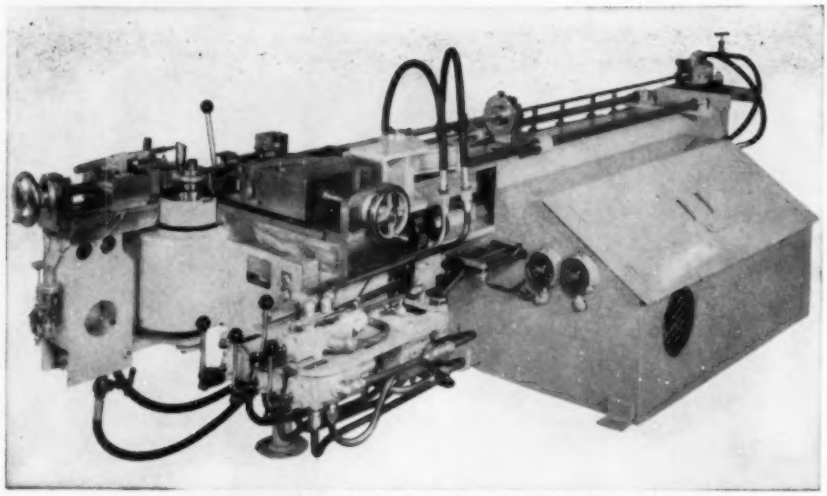

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Flexible enough for mock-up or production.

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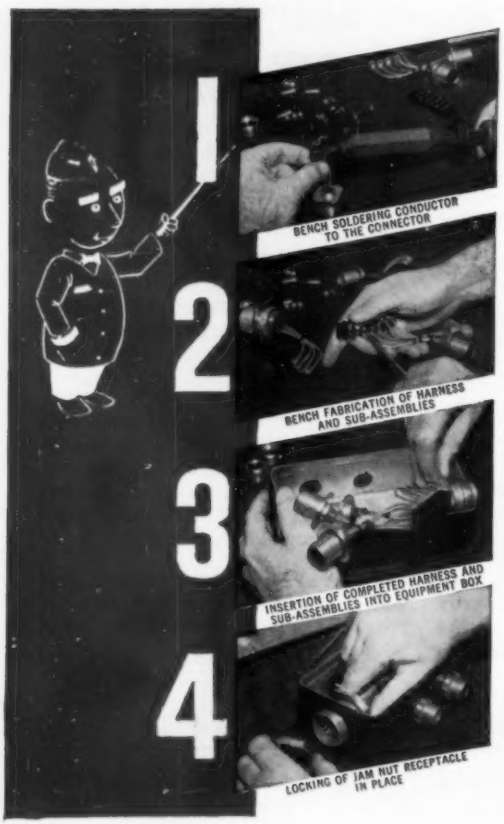
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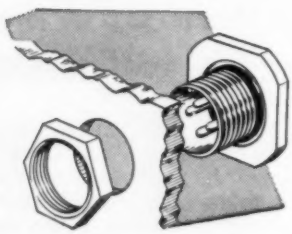
LOCKING OF JAM NUT RECEPTACLE IN PLACE



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Easy to install, to service, to replace

Jam nut receptacles offer such positive savings in assembly time that it will pay you to check into their application on your product. These receptacles permit bench wiring of harness and sub-assemblies prior to final installation with proven savings in assembly labor.

Just consider these design advantages—only one mounting hole required per receptacle—no extra gasket required—no user problem of sealing around screw holes—no extra hardware necessary such as screws, washers or nuts.

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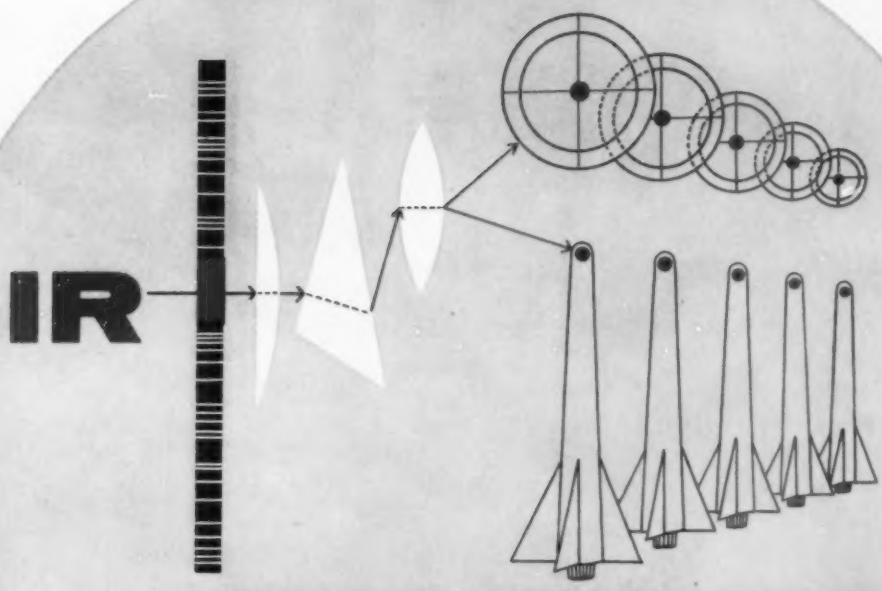

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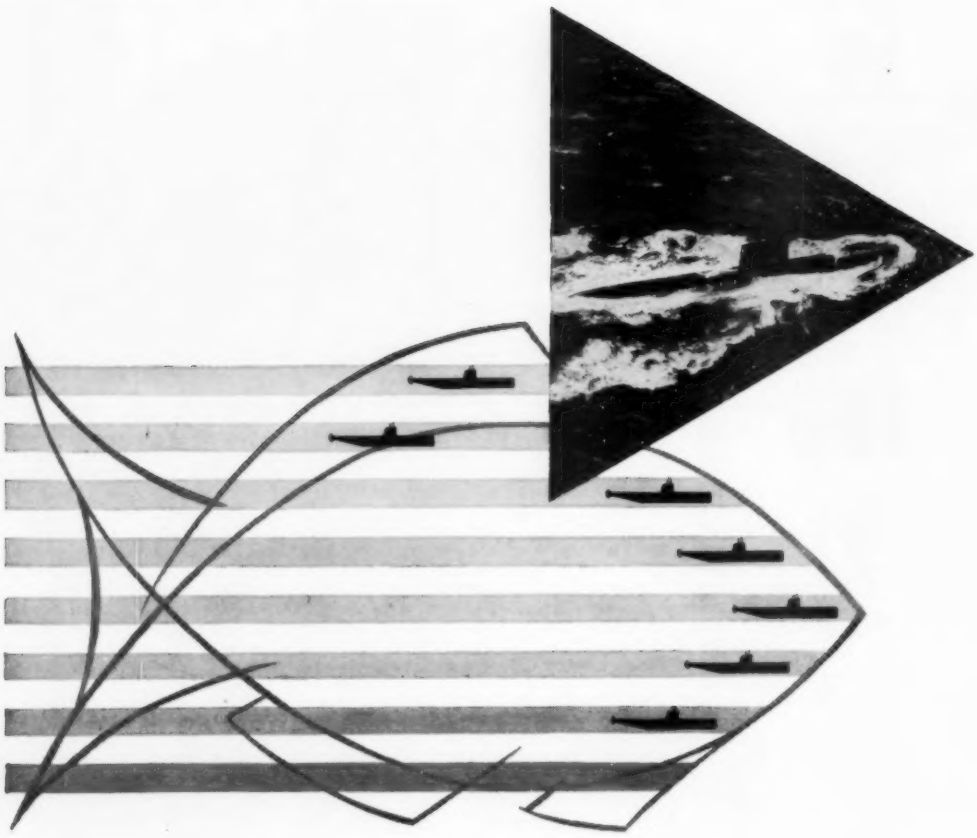

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445 PARK AVENUE, NEW YORK 22, N.Y.

"IF WE HAD ONLY METAL TAGGED SOONER..."

"My inspection team had just finished reidentifying acres of materiel on a Pacific island, when the typhoon struck!" related the Materiel Facility Chief of an Air Force depot. "Every bit of identification that we had put on was gone. All the research that we had done to positively identify the 'lost materiel' had to be redone. If we had only metal tagged it in the first place we wouldn't have had to go to that island. After the storm we had to identify and mark for the third time"

In 1951 Dashew started to work with the Air Force to develop an accurate and durable method of identifying materiel in storage. Since then, billions of dollars of Air Force equipment have been positively identified with rugged, color coded Dashaplates™ that remain clearly legible even in the face of sand storms, tornadoes, typhoons, monsoons, rodents etc. While officials responsible for storage try to warehouse most materiel inside, with ever changing international responsibilities and supply concepts, we cannot have inside storage all over the globe.

Military supply men favored metal tagging because they knew it would (1) assure them of having materiel available, identified and useable in any storage area, (2) it would eliminate costs of reidentification, repackaging and remarking, and (3) eliminate ever procurement due to erroneous inventory based on faulty identification. Based on these advantages, other installations in the Navy and Corps of Engineers have adopted metal tagging.

Thanks to high speed Databosser embossing machines and multi-purpose Dashaplates, the cost of metal tagging is less expensive than other methods of identification. Further, with the portable writing machine, the Datawriter 18, it is possible to write requisitions, inventory and locator cards directly from Dashaplate identification tags, saving writing time and eliminating transcription errors. It allows indigenous personnel, regardless of their native tongue, as well as Americans with poor handwriting, to accurately transcribe records directly from the "identification media."

With the new electronic Databosser it is now possible to create Dashaplates directly from punched cards or tapes at the rate of 1000 or more different plates per hour ... tying identification procedures directly to electronic data processing systems. Send for your free copy of "SIX BONES" SERVING MEN," the full story of Dashew systems and equipment applications. A sound and color slide presentation of this important new concept may be arranged for personnel concerned with these vital problems.

one of a series on Dashew systems and equipment in the armed forces and supporting industries

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Every step in the development of a missile requires critical precision, and not the least important step is the final act of recording the actual flight on film. For such valuable data, the Fonda Corporation has perfected a new method of film processing which guarantees the utmost safety.

Fonda's New Dynamic Drive* features a revolutionary loop tendency drive where tension is so slight that even previously damaged film may be processed without further risk. This, and Fonda's revolutionary new Flexible Building Block System are to be found in the Portable Field Model and in our custom-designed Permanent-Professional installations.

Our skilled engineering staff invites you to use its experience in planning a film processing laboratory designed to suit your own exacting requirements. For further details and brochure, please write to Department TF

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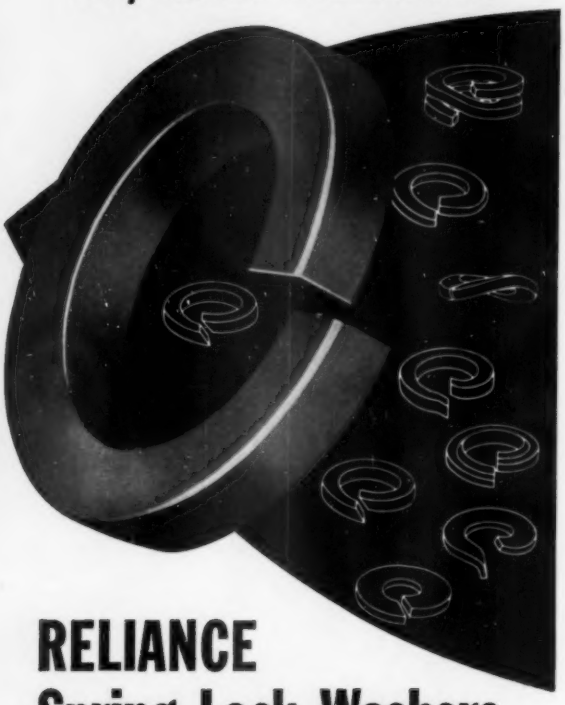
METAL to METAL FASTENINGS

stay TIGHTER with TENSION



RELIANCE
Spring Lock Washers

Metal products assembled by the tried and true nut/bolt method need more than just tight fastenings at the end of the production line. Metal wears, bolts stretch; fastenings can loosen without the nut turning. The solution is the application of constant tension supplied by Reliance helical coil Spring Lock Washers. The reactive pressure exerted will keep your fastenings TIGHTER LONGER. For complete details send for a free copy of Engineering Bulletin W-50.

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true flight!

This Pilot's Dead Reckoning Indicator will track an aircraft's true flight over ranges up to 50 miles . . . and will indicate the position, motion and heading of the aircraft in which it is carried by a spot of light ¼ inch in diameter, projected onto the surface of a translucent grid disc. In the center of this spot of light is an arrow that indicates the direction of the aircraft's heading . . . which will rotate through 360°. Using transistors and other miniature components and techniques our Pilot's Dead Reckoning Indicator is the smallest of its type.

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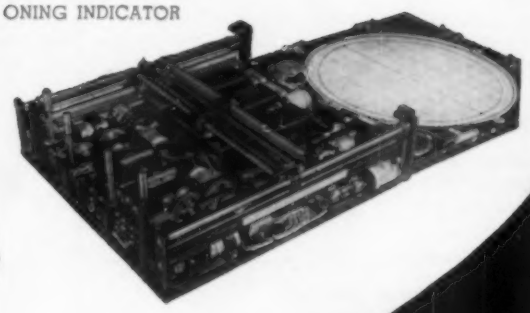

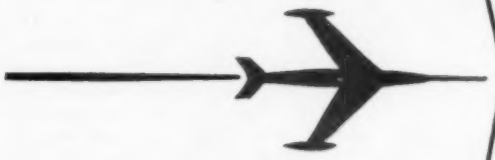

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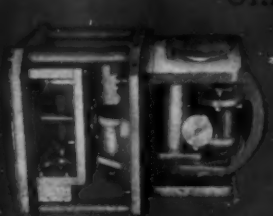
This precision instrument is but one of many which Daystrom engineers have developed—and Daystrom's shop has produced for the Armed Services and industry. You, too, can depend on the "know-how" of Daystrom in development, design and production . . . upon Daystrom's reputation for meeting rigid quality standards and high reliability. Drop us a line, and we'll be glad to have our representative call on you. Or, better still—pay us a visit, and see our modern plant and complete facilities.

OTHER NEW DAYSTROM DEVELOPMENTS INCLUDE



Aircraft All Attitude Indicator

Underwater Servo Control System

Depth Amplifier Test Set

HAVE YOU TRIED THIS EXTRAORDINARY CLEANER?

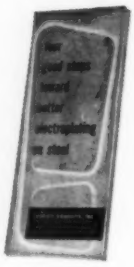
Oakite Rustripper removes rust and heat scale in the same operation that removes oil. It avoids hydrogen embrittlement, damage to machined surfaces and other disadvantages of acid pickling.

Have you taken the four good steps?

How can cleaning costs be reduced 33% while cleaning quality is being improved? *See pages 7 and 8 of booklet.*

What are four easy ways to improve the average rinse tank? *See page 10.*

What causes hydrogen embrittlement during electrocleaning? What is the remedy? *See pages 15 and 16.*



Do you need a brass cleaner that gives better protection against tarnishing?

Oakite has a new brass cleaner that provides scientific protection against the oxygen that tarnishes brass and other copper alloys during the application of reverse current.

"It cut our cleaning rejects by more than 90%"

says a manufacturer who found that Oakite Composition No. 95 gave him:

BRIGHTER PLATING—All films removed . . . no residues, no undersurface shadows, no anodic blackening, nothing to impair the brightness of the electroplate.

FEWER REJECTS—Major causes of blistering and peeling eliminated . . . Consistent success in baking for 60 minutes at 300°F.

OAKITE PRODUCTS, INC.
14F Rector Street, New York 6, N. Y.

Send me the FREE booklets indicated below:

- ☐ Here's the best shortcut in the field of electroplating
- ☐ Four good steps toward better electroplating on steel
- ☐ What's NEW for electrocleaning brass and other copper alloys
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Technical Service Representatives in Principal Cities of U.S. and Canada

ATOMIC ENERGY

NUCLEAR REACTOR SCHOOL

The Atomic Energy Commission has invited proposals from colleges and universities to establish and conduct courses in nuclear reactor technology and supporting subjects as part of a program to double the number of nuclear reactor engineers trained each year at the Oak Ridge School of Reactor Technology (ORSORT) at the Oak Ridge National Laboratory, Tenn.

The program provides that students accepted for the Oak Ridge school will take the first six months of their training at colleges or universities beginning about March 1, 1957, and the remaining six months at Oak Ridge National Laboratory. At the present time the entire one-year course is given at the laboratory.

The universities and colleges were invited to submit proposals under which they would provide preparatory work for the students by giving concentrated instruction in mathematics, physics, chemistry, and engineering. The subjects to be covered in the university phase of the proposed program will be unclassified. The ORSORT portion of the program will cover classified subjects and will be concentrated so as to take advantage of the unique facilities and the latest technology which are available at Oak Ridge.

The proposals invited by the Commission are to cover classes of six months' duration to begin next March. The Commission will enter into contracts for the courses with colleges and universities submitting acceptable proposals.

ORSORT is a graduate-level school providing both the engineer and the scientist with advanced training applicable to the design, construction, and operation of nuclear reactor systems. The first school of its kind, ORSORT was established in 1950 by the Oak Ridge National Laboratory, which is operated by the Union Carbide Nuclear Company, to fill the need for trained personnel in the Commission's reactor-development programs. More than 450 students have been graduated to date.

Applicants for admission to ORSORT may be sponsored by the Commission, its contractors, other Government agencies and their contractors, and industrial organizations having an active interest in development of reactors or reactor components. Under the proposed program, students would be selected by a committee on admissions composed of university, Commission, and ORNL representatives.

DESTINY ON DISPLAY
IBM computer generated display presents moving "situation map" of the skies over New York City. Symbols represent commercial airliners and ground reference.

"INSTRUCTIONS" for a nation's safety!

Heart of America's air defense warning and control system—SAGE—is an IBM electronic computer. In split seconds, if the need should ever arise, the computer will be able to digest huge volumes of data on any invasion of hostile aircraft, report its findings *visually* on a scope! This display of computed data will enable watching airmen to issue "instructions" to defensive weapons with unprecedented speed and certainty.

Computers for SAGE are being produced and installed by IBM to help assure the Air Force of swift, fact-based tactical decisions. Thus IBM's systems engineering skill assists the military in bringing electronic exactness to the task of keeping America alert.

IBM MILITARY PRODUCTS

Engineers! Technicians! IBM offers exciting opportunities to work on computers, control systems, inertial guidance, microwave circuitry—the most wide-open field in the electronics industry. Write: IBM MILITARY PRODUCTS DIVISION, Department 718-A2, 590 Madison Avenue, New York 22, N. Y.

For young men who aim high—the sky's no limit in today's Air Force!

MILITARY PRODUCTS • DATA PROCESSING • ELECTRIC TYPEWRITERS • TIME EQUIPMENT

B52 DECELERATION PARACHUTE

From design to mass production, Security Parachute Company can provide automatic parachute systems for any purpose . . . for the smallest missile or the largest super bomber. Your correspondence regarding research or production is invited.

SECURITY
PARACHUTE COMPANY
SAN LEANDRO, CALIFORNIA

Since 1927

Atomic Energy (Contd.)

SUB ENGINE TEST

The Nation's first practical reactor power plant—the land-based prototype of the submarine NAUTILUS at the AEC's National Reactor Testing Station in Idaho—was routinely shut down recently at the end of what is believed to have been the longest full-power run ever completed by any type of propulsion plant—land, sea, or air.

On a single charge of uranium fuel (and using only part of that charge), the nuclear reactor located at the desert test facility operated at an average power of 100 per cent for more than 66 days and 66 nights. The test was designed to prove the reliability and stamina of pressurized water reactors for ship propulsion, and the reactor met the most demanding requirements that could be placed upon it.

At the end of the 1,600-hour test, the reactor still had many hundreds of hours of full operation available, and it has resumed operation at varying power levels to obtain engineering test data and to train the Navy's atomic sailors. These trainees, officers and men, will man future atomic-powered ships of the fleet.

The test demonstrated the feasibility of nuclear-powered ships cruising at high speeds and without refueling for periods of time hitherto unattainable. Among the important benefits of the test was the obtaining of essential and heretofore unavailable information on reactor performance during extended high-power runs.

To indicate the significance and magnitude of the operation, it was pointed out that if the NAUTILUS itself had made a cruise for this length of time—1,600 hours—she could have steamed at top speed, submerged, around the world and many thousands of miles more.

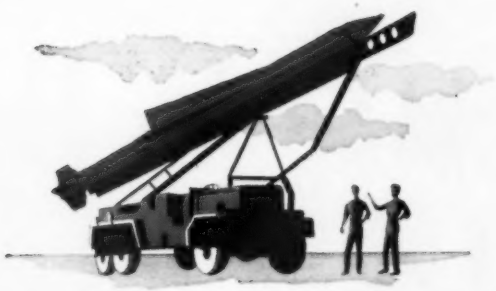
If such a cruise had been made by a Diesel-engined submarine of similar power, about 1,600,000 gallons of fuel would have been required. This amount of oil would fill 160 railroad tank cars, making a freight train more than a mile long.

A-POWERED CRUISER

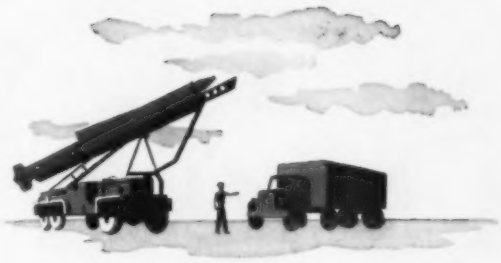
Westinghouse Electric Corporation, Pittsburgh, Pa., has been awarded a contract to furnish reactor compartment components for a nuclear-powered guided-missile light cruiser (CLGN).

The nuclear propulsion plant is being designed and developed by the Atomic Energy Commission in coöperation with the Department of the Navy. This nuclear plant will be the first to be installed in a naval surface ship. Estimated cost of the contract, which is of the cost-plus-fixed-fee type, is $18,335,305.

The cruiser for which the nuclear components are to be furnished is part of the

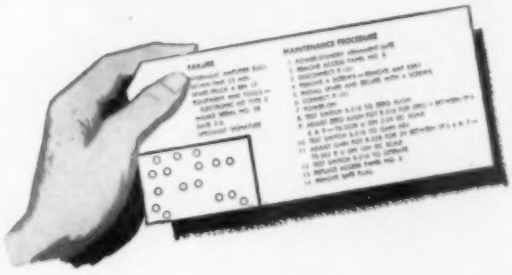


1002 Before launching this missile hundreds of tests must be made — a process usually requiring several hours and highly-trained technicians.

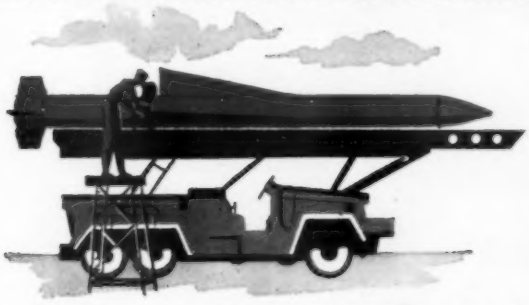


1003 Sperry Check-Out Equipment built into truck is readily moved to launching area to handle all tests.

1008 Inside truck the operator sits at console and by merely pressing button sees micro-filmed information for operational decisions on each malfunction.



1009 Pressing another button operator receives card showing adjustment or repair required and detailed instructions.



1025 With complete instructions for repairs, the check-out is rapidly and accurately completed.

1030 Missile is launched with assurance that its complex mechanisms are operating properly.

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Atomic Energy (Contd.)

Navy's fiscal 1957 shipbuilding program. It will be fitted out with the most advanced armament and guided missiles available for fleet use. Announcement of this assignment to the Quincy, Massachusetts, yard of Bethlehem Steel Company, subject to completion of satisfactory contract negotiations, was made earlier.

THERMONUCLEAR DATA

The Atomic Energy Commission has announced an amendment to the access permit regulation which establishes special conditions for granting access to secret restricted data on controlled thermonuclear processes. The amendment requires that, to qualify for access to the data, an applicant for a permit must:

(1) Be engaged in a substantial effort to develop, design, build, or operate a fission power reactor that is planned for construction; or (2) Possess qualifications demonstrating that he is capable of making a significant contribution to research and development in the controlled thermonuclear field.

The effect of the amendment is to limit access to controlled thermonuclear data to: (1) Those who can give evidence that they are expending significant funds or effort on a specific fission power project planned or in being, so they will have the opportunity to evaluate the potential of controlled thermonuclear processes; and (2) Those who can demonstrate the ability to contribute significantly to controlled thermonuclear development.

SMALL SUB REACTOR

The AEC has approved construction of a prototype reactor plant to power a small submarine. The reactor will be built at the Nuclear Engineering and Development Laboratory being established near Windsor, Conn., by Combustion Engineering, Inc., of New York City. The estimated cost of construction is about $10,000,000. Construction is scheduled to begin in the near future.

The reactor project, designated Project S1C, is based on a requirement of the Department of Defense for the development of a nuclear-powered small submarine. The research and development contract for the reactor and associated systems was awarded in July 1955 to Combustion Engineering, the third major AEC contractor to enter the naval reactor development program. The other two, Westinghouse Electric Corporation and General Electric Company, operate AEC laboratories under contracts with the Commission.

Construction of this prototype will permit the solution of a number of technical problems prior to installing a reactor plant of similar characteristics in an operating submarine.

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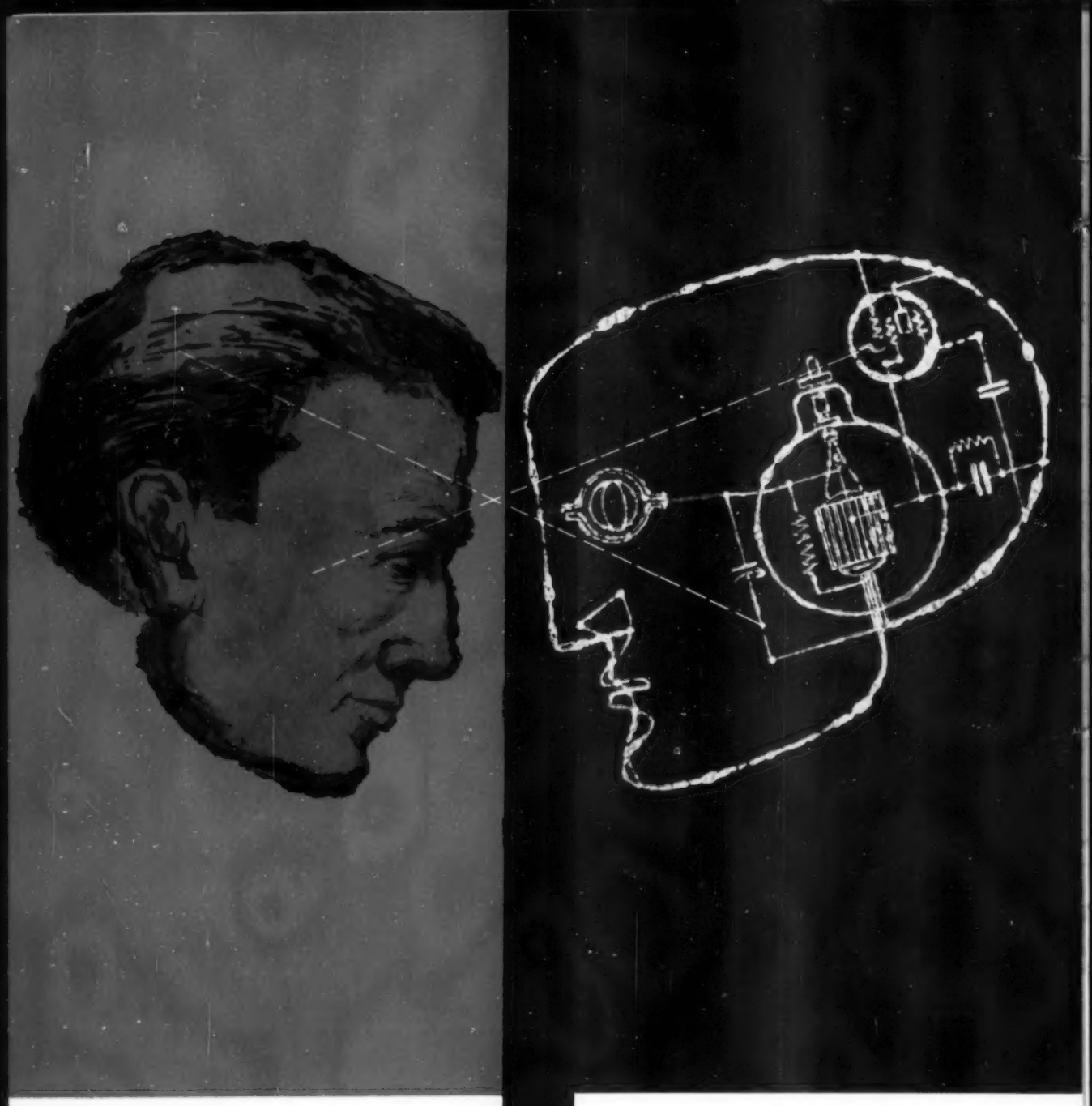

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REAR ADM. JOHN H. SIDES

He helps direct our guided-missile program

The Missile Program

Coöperation among the military will speed development of the new weapons

THE startling climb of scientific and technological developments in the short span of fifteen years has been phenomenal and unforeseen. The terrific acceleration of development is revealed best in the sudden increase in speed with which we can travel after centuries of crawling and the tremendous power made available by nucleonic discoveries.

The jet engine and atomic power units that typify the rapid pace of development in turn have placed demands on all engineering and scientific fields. Requirements seem impossible, yet engineers have confidence that they will develop materials or devices that will withstand the heat of Mach 2, 3, 4, and up, and will guide unmanned weapons with pin-point accuracy.

In the face of these fantastic and rapid developments, planning weapons for the national defense is a task to baffle a roomful of Einsteins. The old cliché that new wars will be fought with yesterday's weapons now seems improbable.

IN the age-old struggle for national survival it is essential to be the country that first produces the latest "ultimate" weapon. The ultimate weapon centuries ago was the cannon, ten years ago the atomic bomb, today the hydrogen bomb, tomorrow the intercontinental ballistic missile, and ten years hence—"Weapon X."

It is natural that in this turmoil weapon planning would get out of hand and central guidance would be needed, particularly when it appeared feasible to combine the hydrogen bomb and the long-range missile to obtain the ICBM, a truly terrifying weapon. This project appeared so complex and to require such a vast array of engineering and scientific application that the resources of the U. S. might be wasted if not coördinated. Consequently, Congress directed the establishment of the office of Special Assistant to the Secretary of Defense for Guided Missiles to oversee all the missile programs of the armed services, with emphasis on development of the ICBM.

Eger V. Murphree was appointed to this position—an engineer of great ability, respected by all, and with a recognized gift of coördinating difficult projects.

With Mr. Murphree's broad knowledge of the engineer-scientist aspects he required only a counterpart, a deputy, to coördinate the users—the military.

HERE was a delicate problem in view of strong service feeling as to the development and utilization of the rapidly expanding families of missiles. It was undoubtedly decided that such an office should be rotated among the services, but the initial choice would have great influence on the long-range effectiveness of the guided-missile program.

It was necessary that the military member of the team must be an officer of sound technical knowledge having great familiarity with all types of missiles and their development history—one who could deftly thread his way through the pitfalls of political emotions, the overexaggerations, and exhorbitant claims of competing interests, and with military judgment based on mature experience evaluate the true offensive and defensive capabilities of proposed missiles. His abilities should also be acknowledged by his contemporaries in the other two services.

The officer selected who is now so capably filling this billet is Rear Adm. John H. "Savvy" Sides, U. S. Navy. To Admiral Sides, the American Ordnance Association offers its fullest cooperation and wishes him success.

Rear Adm. J. H. Sides, Deputy to the Special Assistant to the Secretary of Defense for Guided Missiles, was graduated from the United States Naval Academy in 1925.

After serving at sea in the TENNESSEE and destroyer JOHN D. EDWARDS, he earned his master's degree upon completion of a 3-year ordnance engineering postgraduate course in 1934. His photograph appears on the opposite page.

Then followed three years of cruiser and staff duty at sea, an assignment in the Ammunition Section, Bureau of Ordnance, and again almost three years at sea.

As chief of the Ammunition and Explosives Section, Research Division, Navy Bureau of Ordnance, from 1942-1944, he was awarded the Legion of Merit for his contribution to the development of new fuzes and explosives.

In October 1944 he became commander of the Mine Division, winning a second Legion of Merit in the invasion of Okinawa. After more staff and destroyer duty and a year at the National War College, his direct association with the guided-missile program started in 1948 as deputy to the Assistant Chief of Naval Operations for Guided Missiles.

After a year commanding the cruiser ALBANY he became head of the technical section, Office of Director of Guided Missiles in the Secretary of Defense's Office. In February 1952 he started a 4-year tour as Director of Guided Missiles, Office of the Chief of Naval Operations, during which he was appointed to flag rank in July 1952.

Admiral Sides finally hoisted his flag at sea in January 1956, the first commander of the newly formed Guided Missile Cruiser Division, comprised of the BOSTON, CANBERRA, and NORTHAMPTON.

After a brief sea cruise the Admiral was returned to Washington in April 1956 for his present assignment.

Power—Not Potential

Military power in being must be backed by industrial production power in being if we are to be ready at all times to fight nuclear, psychological and conventional wars and support our present strategy of deterrent force

Comdr. Frank J. Roberts, S.C., U.S.N.

A BASIC policy of the United States is to avoid war, any kind of war, through strength or "forces in being." As we well know, it has not always been thus in our history. For forty years and through three major wars, the United States placed its security in its industrial capacity, but as we entered each of these three wars our nation was ill-prepared. With strenuous efforts, America's "Arsenal of Democracy" was weaned away from its civilian tasks and directed toward building mighty war machines.

With the vast background experience of the World Wars and of Korea, the methods of waging this kind of production war have now become almost a classic art. By allocating critical materials, civilian production can be dried up and a flow of military end items started; manpower skills are registered and channeled into war production; consumer goods are rationed; wages, prices, and rents are frozen; taxes on wages and profits are raised; bond-selling drives are instituted to sop up the extra purchasing power. A horde of alphabetical agencies springs up overnight, headed by big-name business leaders who "breathe fire and direction" into them.

Ponderous as the dance of a circus elephant, the whole mobilization procedure has been relentless in its inevitable success at creating ever-greater mountains of vitally needed war items.

Commander Roberts is planning officer and comptroller of the Naval Supply Center, Oakland, Calif.

It was not the best way to prepare for war, but it was an adequate way. Protected by distance, we also had the time that was required to redirect the efforts of our vast civilian economy to war production.

This time-hallowed process has, however, one basic fault. As a concept, it is hopelessly, irretrievably, and almost completely out of date. It just does not stack up with today's facts of life.

In years gone by, it used to be fashionable to poke fun at the military strategists by saying: "They are planning how to win the last war." Today there is abundant evidence that the military are rather planning for the *next* war with intercontinental bombers, atomic-powered ships, atomic artillery, and "black boxes" of incredible capabilities. Tactics and technology have been welded to produce, in the art of warfare, concepts of mobility and firepower never before dreamed of.

No, it would not be fair to say that the military planners are planning for the last war. But it is fair to say that the industrial planners, the economic mobilizers (and many are wearing military uniforms) are, with a great earnestness, valiantly planning the last war's industrial mobilization with programs and concepts that have no foundation in today's realities.

Before getting into a discussion of our mobilization policies, let us quickly examine the changed nature of war and of the United States facing a war.

The basic weapon of war today is The Bomb, nuclear and thermonuclear. Coupled with the advent of nuclear weapons is the capability of delivering these weapons from one continent to another, presently by long-range aircraft, ultimately by guided missiles. In short, the century-old sanctity of our ocean moats has been breached.

IT does not take a top-secret clearance to appreciate the awful destructiveness of nuclear weapons. The newspapers and magazines have painted the picture clearly enough. It is likely that within the next few years, potential enemies will have the capability of delivering a successful attack that would level dozens of cities, kill or seriously injure many millions of our people, and wipe out the majority of our industrial capacity.

Centers of government, industry, banking, and finance would be wholly destroyed. The Federal Government and the governments of many States would be temporarily leaderless.

These estimates are not the work of Sunday-supplement writers but stem from responsible, informed investigations in and out of Government.

It is axiomatic that the size and nature of our military forces are determined by the size and nature of the military threat. Similarly, any industrial-mobilization planning must be governed by these same factors. Let us examine the kinds of war risks that we are likely to face during the next five years. (See chart below.)

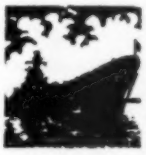
OUR greatest threat is, of course, that of a *general nuclear war*. As we have seen, the dangers inherent in such a war involve the loss of almost everything good that this country has ever known. Our enemies must be deterred from launching such an attack through the conviction that it will bring swift, inescapable, crushing retaliation. It is the constant readiness of our retaliation forces that makes a nuclear war unlikely in the near future.

An "atomic stalemate" does not lessen the need for that readiness. Effective disarmament measures must be sought continuously. But until they are achieved, our strategic readiness must be maintained, regardless of cost, at that minimum level determined by our Joint Chiefs of Staff and our Commander in Chief.

Even though an enemy may not care to risk a general war, he or his allies may well initiate localized or peripheral wars as a means of extending their power. Southeast Asia, the Middle East, North Africa, any of these areas could erupt into active warfare in the next few years. Loss of these areas would not be fatal to our cause, but could seriously affect our over-all position.

Failure to crush the Chinese armies in Korea has greatly reduced our influence and our authority in the whole of Asia. The key to the successful fire fighting of these brush fires lies in the readiness of our allies in those areas and in our own ability to support them instantly with hard-hitting, mobile forces.

We are all well aware that the Reds already have embarked on a war on the psychological-economic-diplomatic front. The good-will tours of the Smiling Troubadors, the sale of arms to Egypt, the promise to furnish India with a steel mill, the purchase of Burmese rice—these are examples of a highly effective "nibbling" process already in high gear.



These actions have had a definite effect on the uncommitted nations—and not to our advantage. To win *this* kind of war, we must be as aggressive and imaginative as in any military war.

The liklihood of a long, drawn-out conventional war of the World War II type is completely rejected. To agree, tacitly or overtly, to a nonuse of nuclear weapons in a general war picture would be national suicide, for it would throw the complete advantage to Russia with, in the words of Winston Churchill, "their immense superiority in conventional forces." Our basic strategy of deterrent power would be completely lost.

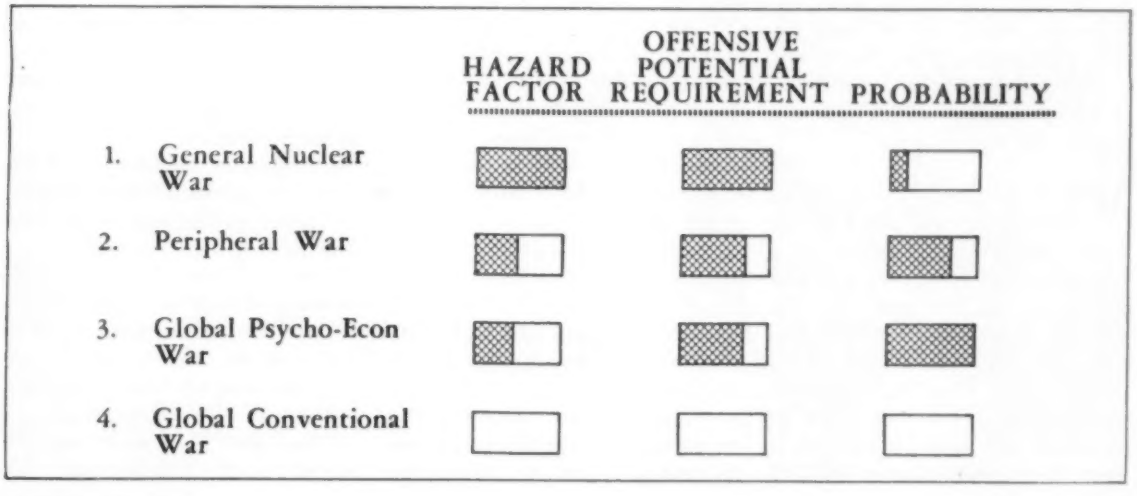
As a practical matter, year by year, we are losing our capability of fighting a large-scale conventional war. As we commit ourselves to the modern weapons, we revise our tactics to suit those weapons. The limits of the budget dollar, of allied manpower, and of the number of hours in a day (for planning and for training), will combine to force us to discard the older tactics. Announcements of the reliance of the NATO defense on atomic power and of the British plan to reduce the personnel strength of their armed forces are indications of the shape of things to come.

Thus we are faced with three, and only three, possible war situations: General Nuclear War, Peripheral War, and Psychological-Economic War. They all have one common factor—the need for forces in being.

TO provide these striking forces we need *industrial production power*. To make these striking forces effective we need a great national resoluteness, a determined singleness of purpose not just to balk the enemy's schemes but also to achieve our own goals.

Let us now assess the adequacy of the second factor—the production forces, usually called economic mobilization. Webster defines mobilization as "the process of assembling into a state of readiness for war."

Types of possible U. S. war risks within the next five years.



There are some who seek another word to describe more aptly our present war-preparedness situation. It is not a new *word* that we need but a new *tense*. For a fundamental fault with current mobilization planning is our failure to think in the *present* tense.

TODAY, we are in a state of cold war. The key word is "war"; we do not call it "hot peace." For almost ten years, the term "cold war" has been imbedded in our minds and vocabularies. Yet, in talking of mobilization, and without even recognizing the incongruity, we still use such terms as "M-day," "in time of emergency," "when war comes." *The* war—today's kind of war—is here!

Our national strategy is aptly called "deterrent power." It requires effective forces in being to combat threats of general war or of peripheral war. To be truly effective, this strategy should be backed by industrial power in being. As history will attest, economic potential has never defeated an enemy.

Let us now turn to some of the more specific phases of national mobilization planning.

Military Logistics Plans.—To a very great extent, the validity of all mobilization planning—that is, the determination and time-phasing of requirements, the allocation of materials and productive resources, the necessary restrictions or incentives applied to the economy—rests with the validity of the basic long-range military logistic plans.

It appears to me that, whatever may be the military *operational* plans, the long-range military *logistic* plans are designed to support World War II style conventional war. They are not designed to support a general nuclear war or a quickly won peripheral war.

WE can only speculate on the nature or duration of any future general nuclear war. But with a high degree of reasonable certainty we can predict that such a war would be fought with the forces on hand, and the military supplies used will be those produced *before* the attack. From the information available, the military can expect no significant help from industry for at least six to twelve months following an attack. Even after that time, military production would be very small as compared with preattack capabilities.

It therefore follows that any military planning that contemplates a postnuclear attack build-up would be specious to the extreme. It follows further that all material determined to be needed in the first twelve months of a general nuclear war be procured and held in stock, that such material be stocked as close to the expected user as is practicable, and that protective storage be provided for such stocks, if feasible.

For a peripheral war it is vitally important that we have highly mobile forces if we are to localize the conflict. Indeed, the availability of such mobile forces would go far toward deterring

such "brush fires." There should exist specific logistic plans to support each specific peripheral war that is likely to break out. Most of the material required for such plans would be common with that required to support a nuclear war. It is conceivable, however, that unique items would be needed for a peripheral war. These items should be specially stocked.

The Rôle of Industry.—Much effort now goes into detailed planning of what industry will be required to produce after M-day. This effort takes the form of detailed computations of end items, of components, and of basic materials. Elaborate time-phasing schedules are made. Company by company, item by item, long listings are carefully compiled. This is largely wasted effort!

If the vast potential of American industry is to be made as influential in world affairs as it deserves to be, it should be in the realm of *production*—not of mythical paper plans.

Mobilization reserve material, whether for nuclear or peripheral war, should be procured and stocked prior to a war. If the material is not actually on hand, the danger of war actually increases.

In previous paragraphs I have emphasized the need for putting our mobilization planning into the "present tense"—the need for recognizing that the emergency is already upon us and the need to construct our policies for a period of long cold war. The organizational alignment proposed supports this concept:

1. No alphabetical agencies should be created at the time of an expanded emergency. Agencies with mobilization assignments under partial mobilization should continue their assignments under total mobilization.

2. The Office of Defense Mobilization should provide policy guidance and adjudicate conflicts during periods of partial *and* total mobilization.

3. Operating responsibilities for specific programs should be concentrated in the "old-line" agencies wherever possible. For example, Selective Service and Civil Service should be placed in the Labor Department.

Whatever merit there may have been in the past to the creation of a host of overlapping agencies in time of crisis, the passage of time and the change of events have rendered invalid. Our war history has shown a continuing struggle to rearrange authorities and to realign organizations. Future events may require some changes, but we are not required to plan for *assured, built-in confusion* at a time when we should be solving the real problems.

The old-line agencies would be required, in some cases, to revamp their views on mobilization responsibilities.

SPACE limitations prevent more than just mentioning other important facets of a revamped mobilization program, such as:

1. Recognition that the Nation can afford, if need be, a considerably larger defense budget without requiring irksome economic controls.

2. The need for a real Civil Defense program, federally directed and permanently staffed.

3. A complete reëxamination of our stockpiling policies and objectives.

Whether we like it or not, we shall have to understand that our precious heritage of freedom and our enviable standards of living must be fought for if they are to be preserved. Faith in our cause and hope for an ultimate true peace must be cherished. But they must be matched with hard-headedness and hard work. The sands of time have run out on other Golden Ages.

Minelaying by Aircraft

Aërial minelaying not only was born in World War II but quickly took the lead over mine-warfare operations of ships and submarines, particularly in the Pacific where such tactics completely bottled up Japanese shipping

William B. Welling

THE use of high-speed aircraft as minelayers provides further means of exploitation for a weapon which is now centuries old. Primitive forms of mines were used by the Dutch in their war against the Spanish in the sixteenth century and again by the Americans during the American Revolution. By the time of the Civil War, the mine had graduated from the gadget stage to the point where three times as many Union ships were sunk by mines as by Confederate gunfire.

In World War II, approximately 218,000 mines were laid during the period of hostilities, with Allied mines reportedly having sunk 150 German ships as against 40 Allied vessels reported sunk by German mines.

The idea of using aircraft to lay mines was considered during the First World War, but nothing came of it. Aërial minelaying achieved notoriety in 1939, however, when Hitler's "secret weapon" turned out to be magnetic mines dropped by the German Luftwaffe off the English coast at the outset of World War II. The mines remained at the bottom until set off by the magnetic fields of passing ships.

As the war progressed, aircraft were used as minelayers extensively by both sides. By using airplanes, waters inaccessible to surface vessels—upstream anchorages, landlocked bays, inland waterways, and closely protected coastal shipping lanes—could be blocked effectively by mines dropped from the air.

Summing up the British view, Capt. J. S. Cowie, C.B.E., Royal Navy, states in his book, "Mines, Minelayers, and Minelaying," that the mine was the most effective antishipping weapon used by aircraft during the entire war. The American Bureau of Naval Personnel Bulletin, *All Hands*, stated in its June 1946 issue that as far as the Navy's mine-warfare experts were concerned, the airplane had become their "most effective minelayer."

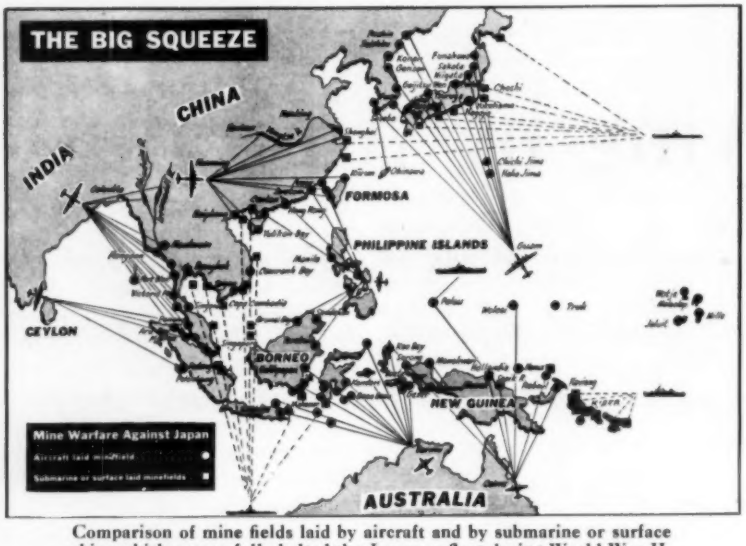
Statistics also tell the same story. Of nearly 76,000 British mines laid during World War II, approximately 55,000 were dropped by aircraft. Of nearly 25,000 mines laid in Pacific waters, some 21,389 were dropped by American, British, and Australian aircraft. Airplanes used in all theaters included B-29, P-38, Catalina, Liberator, Mitchell, Avenger, Swordfish, Beaufort, Albacore, Hampden, Wellington, Manchester, Halifax, Stirling, Lancaster, and Mosquito aircraft.

In the present cold war, defense strategists place great emphasis on the attainment of mobility in their plans to keep America's striking power not only decentralized, but capable of speedy retaliation against a surprise attack. In addition to the normal shipping lanes and strategic targets against which minelaying in all its forms would be employed in the event of another major war, mine-warfare strategists also face the tactical problem of coping with the Red submarine menace which now numbers about 350 undersea craft. These submarines, according to Secretary of the Navy Charles Thomas, are capable of mining most of the vital areas of the world, including our own ports and harbor approaches.

THE Navy has "several new ideas, equipments, techniques, and developments" designed to combat the threat of enemy mine warfare, Secretary Thomas says. Among them are new hunter vessels, new "killer" submarines, new long-range patrol aircraft and blimps, helicopters with listening devices similar to a doctor's stethoscope which can be lowered into the sea at any point, and "homing" torpedoes which will be able to follow, track, and destroy a maneuvering submarine.

And now, too, the Navy is due to get the first seaplane ever designed specifically as a minelayer—the XP6M Martin Seamaster which is being flight-tested at Baltimore. The new swept-wing jet craft is capable of speeds of over 600 miles an hour and will be able to carry a payload of 30,000 pounds.

Mr. Welling is with the information services of the Glenn L. Martin Company, Baltimore, Md.



Comparison of mine fields laid by aircraft and by submarine or surface ships which successfully halted the Japanese fleet during World War II.

At the outset of World War II, only two aircraft—the Royal Air Force Swordfish and the Royal Navy Beaufort—were available strictly as aërial minelayers, each capable of carrying specially designed magnetic ground mines in their standard torpedo crutches. As the war progressed, minor alterations had to be made both in the mines and on the bomb racks of long-range bombers in order to make it possible to step up the mining offensive.

THE record of aërial minelaying operations in World War II affords ample proof of the strategic and tactical significance of this form of modern mine warfare. At the same time it provides a good indication of the important rôle which a new weapon such as the Seamaster would play in a future war, where its unique capabilities of performance and wide global dispersion would offer superior aërial means for throttling enemy submarine and shipping movements. As a seaplane, the Seamaster would not, for example, be restricted to the fixed-base facilities needed for land planes—which occasionally imposed limitations on aërial mining sorties during World War II.

One example was the curtailment of minelaying missions by Fourteenth U. S. Army Air Force B-24 bombers based in India when a Japanese offensive late in 1944 forced the planes out of range of the China coast where they had been laying mines from the Tonkin Gulf in the south to the Yangtze River in the north. Royal Australian Air Force Catalinas, under the command of the U. S. Seventh Fleet, took over these missions as soon as bases became available in the Philippines.

Similarly, the Fourteenth's mining missions on the China coast, which had to be flown over the Hump (highest peak about 25,000 feet), would no longer demand the effort or fatigue of crew members aboard the modern multijet bomber or seaplane which can cruise normally at 40,000 feet or above.

THERE are numerous examples of disruptions inflicted on the enemy's industry as a result of aërial mine drops in key strategic waters. Eleven mines laid by RAF Mosquito planes in the Kiel Canal in April 1944, for example, are reported to have caused the virtual loss to the Germans of over 1,000,000 metric tons of cargo, simply through the dislocation suffered by industrial plants dependent on shipping. Frequent industrial suspensions were also caused by mine drops which disrupted iron-ore traffic from Scandinavia to the Ruhr and halted enemy ships carrying supplies over the short distance from Bilbao in Northern Spain to Bayonne in Southern France.

When American B-29's conducted their five-month aërial blitz at the end of the Pacific war, dropping 1,200 mines around the Japanese homeland, leading Japanese industrialists are reported to have informed the militarists shortly before the surrender that not only could industry not continue to operate if the blitz went on but that 7,000,000 Japanese would starve to death within another year.

In retaliation against the initial German mine drops in the summer of 1939, RAF Swordfish airplanes laid mines in the Scheldt and Lubeck Rivers, the Kiel Canal, and in the waters off the Norwegian coast (including Oslo Harbor itself). British naval aircraft, just after the fall of France, carried out the first carrier-borne minelaying operation in history, laying mines in the Mediterranean Sea off the Algerian port of Oran. These airplanes also laid mines off Sicilian ports and in Mediterranean waters north of Tripoli during the summer of 1940 and again mined the Kiel Canal the following December.

DURING 1941, Allied aircraft minelaying operations appear to have been confined solely to the Mediterranean. This situation was due largely to the fact that there was a decided premium on the number of airplanes which could be made available for aërial minelaying. Strategywise, broad plans were formulated by the British Admiralty, while the detailed planning and execution of these operations were carried out by the Bomber Command.

By the end of 1942, these operations were centered on coastal ports in the Bay of Biscay in order to help prevent attacks on Allied convoys headed for North Africa. During 1943, the Mediterranean ports of Sfax, Trapani, Olbia, and Catania were mined by the RAF, while on two nights in April of that year aircraft of the Bomber Command performed what was then considered a "remarkable feat" by flying from England across France, Switzerland, and Northern Italy to lay mines off the port of Spezia.

The year 1943 saw the beginning of American aërial minelaying operations in the Pacific. Although 30,000 to 40,000 tons of shipping were passing weekly along the Rangoon River, it

was not until January 1943 that U. S. airmen could obtain both suitable British mines and the necessary technical assistance for aërial operations from RAF and British naval sources—assistance which also produced information on harbor channels, tide movements, and even moon phases in the areas where aërial minelaying was planned.

ON the night of February 22, 1943, while the moon was full, the tide low, and a diversionary bombing mission had been dispatched over the city of Rangoon itself, ten modified B-24 Liberators of the Tenth U. S. Army Air Force based in India dropped forty British magnetic mines in the Rangoon estuary. With the magnetic mine, the planes could be protected in flight by a gap in the mine's electrical circuit which was kept open until closed by water pressure acting upon a hydrostatic plunger.

After this mission, a vigorous minelaying campaign in this sector of Southwest Asia was begun. In the South Pacific, Navy and Marine Corps TBF Avenger airplanes began their first aërial minelaying operations in the Solomon Islands, striking at Bougainville on the night of March 20, 1943, with a force of forty-two aircraft. The mines dropped are reported to have caused the sinking of a 6,400-ton merchant vessel nearly a month later, in addition to damaging another cargo ship and an enemy destroyer.

During this mission, however, the pilots faced the hazard of Japanese searchlights which picked up their Avengers as they parachuted the mines from altitudes ranging from 800 to 1,300 feet.

In April, RAAF Catalinas opened their minelaying campaign in the Territory of New Guinea, laying sixty mines in an area at the north end of New Ireland where the Japs planned to make a fleet anchorage. The anchorage was subsequently abandoned. For the remainder of the war, the RAAF contined to perform virtually all aërial mining operations in the Southwest Pacific.

THE Pacific war was divided into an "outer-zone" mining campaign, which involved all types of Allied planes and lasted the entire length of the war, and an "inner-zone" campaign, which refers to the B-29 aërial blitz during the last five months of hostilities. The outer-zone campaign is reported to have choked 150 enemy harbors and shipping canals with nearly 13,000 mines (more than 9,000 laid by aircraft) and hampered the flow of troop supplies and raw materials.

Because there was seldom a large enough concentration of merchant vessels within the range of U. S. bombers operating in the China seas to justify an intensive search for them at any given time, persistent drops were made at enemy-held ports in regular use. Time-delay mechanisms were frequently used on mines dropped from the air which made the waters in Malayan ports become charged with danger as long as a month after a given mission.

FOR two months, beginning in December 1943, heavy bombers from Tarawa and Apamama placed mines at the entrances to harbors on four islands which were to be bypassed in the invasion of the Marshall Islands. In the early months of 1944, the RAAF planted approximately 400 British and American mines in 21 harbors in the territory of New Guinea and the Bismark Archipelago, an operation which involved some 200 missions and the loss of only one plane.

On March 31, 1944, specially equipped squadrons of Avengers from the carriers LEXINGTON, BUNKER HILL, and HORNET, began mining two passages off Palau Harbor in the Palau

Built for minelaying and photo-reconnaissance missions, the Seamaster is the Navy's new 600-m.p.h. attack seaplane.

Islands. This operation is reported to have bottled up thirty-two enemy merchant ships and tankers in the harbor where the ships were subsequently destroyed by our bombers. In April, the islands of Truk and Woleai were mined by aircraft, and during the summer RAF and Tenth Air Force aircraft based in India and Ceylon flew some 200 sorties, laying almost 1,000 mines in 11 regions along the coast of Burma, Thailand, and the Malay Peninsula.

AS larger numbers of Lancaster aircraft became available in Europe—each capable of carrying six mines—British aërial minelaying missions in European waters were stepped up. In addition, equipment was developed by the British which enabled the dropping of mines with accuracy from heights of 15,000 feet. Between April 17, 1944, and D-Day, aircraft of five British Bomber Command groups conducted Operation Maple—a threefold attack against enemy U-boats, shipping, and troop movements by sea. Nearly 4,000 mines were dropped during this operation. Mosquito airplanes again mined the Kiel Canal, and the Lancasters, flying practically at water level, mined the Koenigsberg Canal. Attacks were carried out against the movement of troops and stores from Norway and Germany's eastern front.

In May, Liberator and Wellington aircraft of the Mediterranean Allied Air Force began a series of drops in the Danube River, and by October approximately 1,200 mines had been placed. This single operation, in which 200 enemy ships of all kinds were reported sunk, is credited by the British with having produced the highest casualty rate per mine achieved in any area during the war.

AS Operation Maple got under way in Europe, the first acoustic mines to be dropped by American aircraft in the Pacific were planted in the harbor of Balikpapan on the island of Borneo on April 20, 1944. These mines were actuated by the noise of ships passing overhead.

On August 10, the first B-29's were used as minelayers, flying from India to plant mines in the harbor of Palembang on the island of Sumatra. Some of the B-29's flew high, others low—so low that one reportedly strafed an enemy tanker in the harbor channel. Seven ships were reported sunk as a result of this raid, and the port was closed for a month.

A Mark 26 magnetic mine is photographed during actual drop from a B-29 at Chichi Jima in World War II (Air Force photo).

From November to the end of the year, B-24 Liberators of the Seventh U. S. Army Air Force heavily mined the Bonin Islands (between Iwo Jima and Japan) in support of the Iwo Jima invasion.

FROM January to March 1945, airplanes of the Fourteenth U. S. Army Air Force based in India operated over the Hump, laying more than 300 mines in the upper Yangtze River and over 100 floating mines upstream from such ports as Hankow, where they floated down on ships and barge traffic. In January, too, India-based B-29's again commenced aërial minelaying missions, dropping magnetic mines in the approaches to Singapore, Saigon, and Cam-ranh Bay. During a single week in this month, nearly every usable port on the Malay Peninsula was again mined from the air.

The final aërial blitz of the war—the inner-zone campaign—began March 27, 1945, and continued until August 15th. Between March 27th and May 2nd, B-29's from Tinian dropped nearly 1,000 magnetic and acoustic mines in the Shimonoseki Straits where Japanese shipping passed to the industrial ports on the Inland Sea of Japan. The naval ports of Kure, Sasebo, and Hiroshima also were mined. From May 3rd to 12th, nearly 1,422 mines of all types (including new pressure mines) were dropped in the main shipping lanes of the inland sea, and the ports of Tokyo, Nagoya, Kobe, and Osaka received special attention.

A third phase of the campaign, from May 13th to June 6th, involved mine drops in the harbors of Kyushu and the northwest Honshu mainland. Between June 7th and July 8th, the Shimonoseki Straits were again mined as were the ports of Kobe and Osaka.

AËRIAL minelaying was not only born in World War II but quickly took the lead over the mine-warfare operations of ships and submarines, particularly in the Pacific where operations were far-flung over an area twenty times the size of the United States. The trend has been evidenced in other operations.

Former Assistant Secretary of the Navy for Air James H. Smith, Jr., has pointed out that "if you look back over what has been going on in the Navy, you will see that air has been taking over more and more duties. The patrol used to be done by ships; it's done by flying boats today or land planes. Such things as the early-warning picket ship, that used to be a destroyer in World War II, is today our R7B (a radar Super Constellation). The destroyer that used to provide the antisubmarine screen for the task force is being replaced largely by the helicopter.

Aircraft utilized as minelayers, the Navy says, must have maneuverability, long range, and high speed at the lowest altitudes in order to be able to evade enemy counteraction. To this end the Seamaster has been developed as the first aërial minelaying seaplane capable of speeds of over 600 miles an hour.

Use of an aircraft such as the Seamaster makes it possible to provide a "guerrilla type of operation" for sea forces similar to that which has been recommended for land forces.

War and History

An analysis of the final volume in the distinguished series on the military history of the Western World by Maj. Gen. J. F. C. Fuller, covering the period from the Seven Days' Battle, 1862, to the Battle of Leyte Gulf in 1944

Hoffman Nickerson

GENERAL FULLER has seen much fighting, including service against the Boers in South Africa and against the Germans in France in 1914-1918. He was chief of staff of the British Tank Corps in which he was largely responsible for planning the Cambrai break-through which, if adequately supported by General Haig, would have moved the Western Front far to the eastward a year before the Armistice.

General Fuller was also an observer with the Italians in Abyssinia in 1935 and later with the Nationalists in Spain. His many books have made him the foremost analyst of war in the English-speaking countries, and this third volume of his "Military History" confirms his position. ("A Military History of the Western World," Vol. III. New York: Funk & Wagnalls Company, 666 pp.)

His self-imposed task was immense. The first volume began with the battle of Megiddo in 1479 B.C. and ended with Lepanto in 1571 A.D.; the second took up the story with the Spanish Armada in 1588 and carried it through Waterloo in 1815.

IN Volume I the reviewer vividly remembers the sketch of the campaign of Philippi in the Roman Civil Wars with the uncertainty of the generals on both sides for fear that their troops might go over to the enemy like the levies of Central American revolutionaries.

Mr. Nickerson is a well-known American military historian and author of several books including "Can We Limit War?" and "The Armed Horde."

In Volume II the account of the Waterloo campaign stands out, with its tide of errors first on one side and then on the other.

Volume III, from the Seven Days' Battle, 1862, to the Battle of Leyte Gulf, 1944, covers a vast field strewn with the bodies of wounded but by no means dead controversies, beginning with a short chapter on the Industrial Revolution and what the author piquantly calls "the rise of American imperialism" and ending with an equally brief discussion of "the Second World War in retrospect and in prospect."

Since battles are incidental to campaigns, and campaigns incidental to the attempts of human groups to enforce their will upon one another, the account of each battle must include the strategy which brought it about and something of the political aim which the strategy was designed to serve.

Also, when one war arises out of a political situation different from that which provoked the last conflict, then there must be a short connecting "chronicle" to explain how the second situation arose. Thus if the volume in question had been given an omnibus title in German fashion it might have been: "A tabloid history of Western Civilization since the Revolutionary-Napoleonic Wars and the Industrial Revolution, stressing the effect of military operations."

We have said that General Fuller's subject is full of controversies not in order to dispraise his book but to praise it. Unless there is frank and fairly conducted controversy, how can any disputed matter be decided intelligently? The author, to his honor, "pulls no punches" and never hits below the belt. If space permitted, it would be pleasant and, let us hope, profitable to debate some of his opinions. The fact remains that he has touched nothing which he has not enlightened.

One point the book makes beyond all question—the enormous influence of purely military events upon general history. For instance, General Fuller ends his chapter on the Seven Days' Battle of June and July 1862 as follows:

"The importance of the Seven Days' Battle lies in what it did not accomplish. Had McClellan lost his army, which except for Confederate blunderings he might well have done, the possibility is that the Union would have been temporarily lost with it; and had Lee lost his army, and with it Richmond, which except for Federal blunderings might easily have happened,

then as Samuel Eliot Morison and Henry Steele Commanger point out in Volume I of their 'Growth of the American Republic': '. . . the horrors of reconstruction could not have occurred, slavery would not have been abolished by violence, or Southern society gutted, and the South would have had some voice in whatever means of gradual emancipation might subsequently have been adopted.'

"Therefore the political importance of this first of the great battles of the Civil War is that instead of shortening the war it prolonged it by nearly three years and by doing so it shaped its aftermath."

A GLANCE at almost any newspaper today is enough to show that that aftermath is not ended.

After the opening "chronicle" and the chapter on the Seven Days' Battle there are two more chapters on the American Civil War, two on the rise of Prussia and the first Battle of Sedan in 1870, and two on Russia and Japan in the Far East.

Next there is a brilliant study of "the foundations of the First World War." The author scorns the angel-devil theory of 1914 and takes his stand with the "revisionist" historians who have so thoroughly picked the bones of Woodrow Wilson's disastrous "idealism." He shows how trouble began with the intemperate language of the vain and theatrical Kaiser Wilhelm which led first to the Franco-Russian alliance, then to the British propaganda against the German Navy. All this culminated in the Anglo-French treaty of 1904.

With reference to that treaty General Fuller quotes Adm. Sir John Fisher's forecast of 1908 "that should we be led into a . . . tacit pledge . . . to land a British Army in France in a war against Germany, then would come the biggest blow to England she would ever have experienced—not a defeat . . . but a deadly blow to our economic resources and . . . the relegation of the British Navy into a 'subsidiary service'."

Given the fragility of an economy based upon overseas trade and the inability of the general staffs to foresee the trench deadlock, the results of 1914-1918 were disastrous not only to England but also to all the other original combatants except Japan.

"Germany was reduced to economic ruin . . . Russia ceased to be a Christian country, and the autocracy of Marx was substituted for that of the Tzars. The Austro-Hungarian Empire was split into . . . squabbling states bereft of economic foundations . . . France, bled white, was left a demoralized second-rate power; Great Britain . . . before the war . . . the banker of the world, ended a debtor country. . . . The United States was left to pay for the war she had so blindly entered."

Such were the fruits of the great struggle to make the world safe for democracy.

Had the United States not declared war early in 1917, the English and French might well have made a compromise peace which would have left Russia non-Communist and Europe still substantially intact.

After World War I, General Fuller discusses the 1920 Battle of Warsaw in which the able Pilsudski, correctly judging that the trench warfare complex was unsuited to the vast theater of war and the comparatively small and ill-equipped armies, defeated that strange man Tukhachevski who hoped to throw the whole Continent of Europe into revolutionary chaos.

Next the book considers the rise of the Third Reich and the origins of the Second World War. Hitler, part genius and part crazy fanatic, awakened a racial crusading spirit in Germany, criminally ill treated the Jews there, challenged the power of world Jewry, and set up a system of barter trade which threatened the economic systems of the U. S. and England—based as those systems were on international finance.

The British, instead of allowing the Germans to entangle themselves in a war with Russia, declared a second "ideological crusade" against resurgent Germany. Churchill is quoted as having said in September 1939: "We are fighting to save a whole world from the pestilence of Nazi tyranny and in defense of all that is most sacred to man."

At first the German plane-tank teams —patterned after those planned by General Fuller in World War I, as his book modestly does not say—won a series of lightning victories with insignificant losses to themselves and losses in prisoners more than in dead and wounded to their opponents.

The author calls the air battle of Britain "a gigantic bluff" by the Germans, a bluff in which no German leader except perhaps Goering believed. In practice it was "a grotesque failure . . . never once were the British Isles in any real danger."

With England led by the pugnacious Churchill still unconquered and President Roosevelt doing his best to get the United States into the war, Hitler unwisely turned away from the Mediterranean theater to move into the vast Russian spaces.

Next the Japanese attacked Pearl Harbor—a move which was tactically successful but fundamentally unwise for the assailants since it brought the United States in against them and thereby assured the defeat of both Japan and her German allies. The story is continued by chapters on Midway, El Alamein and Tunis, Stalingrad, Normandy, and Leyte Gulf.

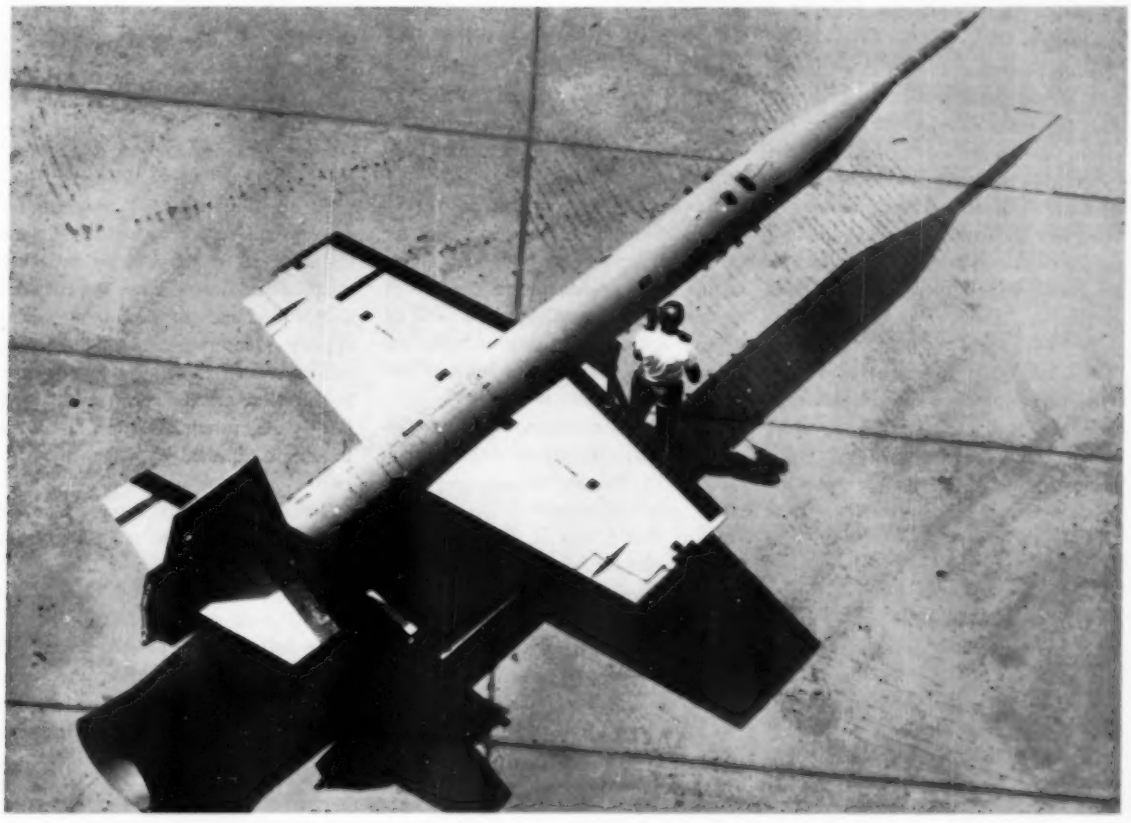
THE results of 1945 were even more unhappy than those of 1918. The demand for unconditional surrender needlessly prolonged the war both in Europe and in Asia. General Fuller exposes the fable that the atomic bomb shortened the war against Japan—the Mikado had been trying hard to surrender for some time. Only the folly of insisting upon unconditional surrender had stood in the way, and this formula had to be modified even after the bombs were dropped.

Churchill is aptly quoted on the failure of his own politics: "After all . . . the victories of the Righteous Cause we have still not found peace and security, and . . . we lie in the grip of even worse perils than those we have surmounted."

What an epitaph on the muddled twentieth-century crusading spirit!

New Aërial Developments

The giant Douglas C-133 cargo airplane, above, has a payload capacity of 100,000 pounds and has lifted its design gross weight of 250,000 pounds. The Lockheed X-7 Flying Stovepipe, below, is a supersonic test vehicle employed by the Air Research and Development Command in the development of ramjet engines and other components for use in guided missiles (Air Force photos).



A New Defense Outlook

American industry has learned much from the lessons of our past wars and almost all of our important manufacturers today are engaged in the production of military items or have had such previous experience

Francis Walton

TO a people existing under the conditions of a perpetual "cold war" which at any moment might turn into a very warm one, the question of the chances of victory in the second situation must inevitably become an ever-present concern.

To answer it, the important contributing factors of former successes must be called to mind and weighed in the light of present performances.

It has become axiomatic that the victory of the nations allied against the Axis powers in World War II was the result in the largest measure of the might and efficiency of American production. To get the answer now sought, not a few challenges must be addressed to the watchman who stands on the ramparts of the American home front of production.

IT is comforting to know that we will not have to shout our queries quite so loudly as was once necessary. More important and more comforting, this time the watchman will know what we are talking about. But before he can answer fully and intelligently, he may have some queries of his own, and among these we must not be surprised to hear: "What kind of war?" "Will it be instantly total, or will it become gradually so?" "Will it be confined to one area—at a great distance—or to many small ones all over the globe?" "Will the *casus belli* result in an initial devastating strike at the heart of the homeland?" "Will it be fought by great human forces, or more or less completely with a limited number of knowledgeable Davids supplied with extremely accurate electronically controlled slingshots?"

Mr. Walton is author of the recently published book, "Miracle of World War II," which was discussed by Brig. Gen. Donald Armstrong in the July-August 1956 issue of ORDNANCE *magazine.*

But since these are questions in cross-examination which no one can answer satisfactorily, the original query must stand more or less on its own, with particular reference as to how well industry is keeping in step with the unprecedented changes this military uncertainty demands.

The most satisfactory reply must begin with an examination of the relevant factors of the industrial production success of World War II, the conditions upon which those factors were founded, and how those factors and conditions have changed, for either better or worse.

The maintenance of the "cold war" must be considered the first great mistake of The Enemy in the hot war if it should come. The neutralists as well as the nations which are the avowed ideological opponents of America must be credited with a substantial contribution to the making of this error—in our favor. With the former in the rôle of confirmed allies, there would be greater complacency and less industrial preparedness—the traditional American mistake.

THIS is the first great difference. It has its roots deep in a changed American public opinion—an expressed viewpoint which, for once, has been more or less adequately translated into political action. The Eighty-fourth Congress approved an arms program for 1957 of $33,635,000 to maintain the strongest peacetime military establishment in American history. Maintenance of this kind and on the scale for which appropriations were made inevitably means industrial activity for defense. Its very size precludes its confinement, largely the custom of other peacetimes, to the established Government arsenals.

Thus, in three quick steps we have come to an important major change—and to the door of the American factory—referred to in our late great trouble as the Arsenal of Democracy.

Pertinent as a symbol growing out of this national concern are the activities of one of the largest food-milling companies of the Nation. At the time of Pearl Harbor, General Mills, Inc., had a rough time breaking into war

production. And the trouble was not so much in actual conversion as in convincing the military that a food-processing company could play a vital rôle in manufacturing the hardware of war. The attendant lapse will not occur again.

Partly as a result of its splendid record in proving that contention, General Mills today is a going partner in the national-defense program. It has been carrying on an essential project in the interest of military upper-air exploration. One of its current fields of activity is the study of the erosion of metal vehicles in hypersonic flight in the ionosphere and outer space.

Activity of this kind for military preparedness in the disastrous 1930's would have been (1) a 7-day wonder, (2) a subject of derision, and (3) a target of criticism of jingoism.

The changes relevant to American industrial preparedness are to be found both in the front office and out on the benches of the production areas in American factories today.

THE initial crisis, and it was almost catastrophic, in producing for victory in World War II was in machine tools. Industrial readiness must be assayed first of all in terms of the tool situation. The current condition in one vital industry—that of aircraft manufacturing—will suffice as a key to the picture.

The latest inventory available in this field shows 145,000 machine tools with an acquisition value of $1.4 billion. Of these, approximately sixty per cent are the metal-forming or metal-cutting type. The danger in assessing the worth of this hoard is neglect of concern for erosion through obsolescence. And here lies the true significance of our industrial strength today.

The danger mentioned does not appear to have been overlooked. Full consideration is being given to it through provision for a purging operation, closely supervised by the Air Force, which will reduce the inventory by 4,000 to 5,000 units yearly—with essential replacements being automatically demanded.

"The postwar tendency of American industrial organizations, particularly those of the middle-sized group, to merge has been widely noted. . . . The movement has tended to remove the serious handicap of undue specialization of individual businesses in peacetime. . . . This broadening of the base of activity of American companies (begun) under the emergency requirements of World War II . . . has been extended under the pressures of the 'cold war,' aided and abetted by the Korean 'police action.'"

Toward the end of World War II, with the disclosure of a trend which has continued to develop, much concern was expressed over the growing complexity of the machines of war. It was held that "next time" there would not be enough time, that victory would be impossible because of the increasing technical complications which would preclude production in anything approaching the essential quantities.

The warning was not without soundness and a measure of validity. But since the trend has survived in mass manufacturing of peacetime civilian products, the warned-of danger is under continuous study, familiarization, and attack. The postwar development of the transistor and its adaptation to myriad microscopic mechanisms is a case in point. The solutions being found will be automatically available in the event of military crisis.

A recent study made by the Aircraft Industries Association shows that today's complex aircraft—and the increased labor charges would be the first factor to disclose possible defeat in the face of complexity—cost less pound per pound than the simpler models of ten years ago.

For example, while the actual price of an F-100 is many times more than that of its predecessor, the F-51, manufacturing techniques in use today can overcome this change to permit production of more airframe pounds per man-hour than during World War II. The skills in available manpower are proportionately higher.

The handling of the always provocative and disruptive problems of automation by management—the laying of the ghosts which always attend it and its continued progress—are significant assets in industrial preparedness. A striking example comes to mind. In the machining of the wing skin of an airplane it is now possible to reduce machine time from 130 hours per piece to 12.2 hours. This has come about through the ability to transfer to an automatic machine a task formerly performed by hand.

BY the best present estimate, approximately thirty-six per cent of America's scientific research and development is directly concerned with problems of national defense. This, it must be admitted, is significantly lower than some European countries can show.

It is fair to assume that Russia's may be close to total. In England, sixty per cent of the nation's research funds are being devoted exclusively to the military field, according to figures made public at the annual meeting of the British Association for the Advancement of Science, held in Sheffield in September 1956.

However, the discrepancy revealed in percentage figures does not mean much. The ability to shift brain power in American industrial laboratories from civilian problems to those of the military was one of the outstanding achievements of World War II—a change-over unmatched anywhere else in the world.

United States industry is currently employing about six times as many science graduates as Great Britain, and its expenditures on civil research and development are far in excess of those of any other nation.

The postwar tendency of American industrial organizations, particularly those of the middle-sized group, to merge has been widely noted, commented on, and, in specific instances, severely criticized. The legal propriety in each case may be properly left to the Department of Justice. The movement, over-all, has tended to remove the seri-

ous handicap of undue specialization of individual businesses in peacetime.

The larger corporation developing from the merger of a number of noncompeting companies brings about a wider scope of manufacturing interests and experience and creates an organization which somewhere in its varied production divisions offers one or more services to the military. The effect is an invaluable ordnance contact in peacetime, which filters familiarity with Government procedures and defense awareness through all its associated units.

The trend toward lessened specialization began in the largest manufacturing companies as a result of the sudden unexpected emergencies of World War II and has become a continuing movement of great value to national defense.

IT is perhaps most graphically illustrated in the case of aircraft engine production. Prior to World War II, all the business available in this field was competed for largely and in the healthiest fashion by two companies. By the same token, the science of this industry remained in a measure archaic and highly secretive and exclusive.

To satisfy the demands of World War II, the techniques had to be taught to the automotive industry in terrific haste to meet the need for engines in quantity—a remarkable accomplishment but one nonetheless burdened with the greatest dangers.

When in the course of World War II an entirely new means of powering aircraft—jet propulsion—made its appearance, the emergency task was not assigned exclusively to the existing aircraft engine companies but to units of the automotive and electrical manufacturing companies as well.

The seed planted has grown vigorously and variously. Jet propulsion is not today the sole concern of the old-line air-engine manufacturers. There exists as a consequence in Westinghouse, General Motors, and General Electric a concrete interest in the production of propulsion power for military aircraft.

This broadening of the base of activity of American companies under the emergency requirements of World War II has been extended under the pressures of the "cold war," aided and abetted by the Korean "police action."

"By the best present estimate, approximately thirty-six per cent of America's scientific research and development is directly concerned with problems of national defense. This, it must be admitted, is significantly lower than some European countries can show. . . . However, the discrepancy revealed in percentage figures does not mean much. The ability to shift brain power in American industrial laboratories from civilian problems to those of the military was one of the outstanding achievements of World War II—a changeover unmatched anywhere else in the world."

The Department of Defense recently saw fit to announce the development of a new aircraft weapon, the T-171, to arm the F-104 and F-105 fighters as well as the B-58 supersonic bombers. It is a complex, 6-barreled cluster gun rotated counterclockwise. It is a 20-mm. cannon that can spew forth 8,000 shells a minute and was developed and refined under the supervision of Army Ordnance by the General Electric Company whose first World War II experience in arms production was a laborious copying of an antiquated 75-mm. pack howitzer.

The contract for the latter emergency job was let on September 23, 1939, a time when few at G. E. (their engineers and executives would be the first to admit this) knew one end of a gun barrel from the other.

To grasp the present measure of the broadened base of American industrial interest in, and to understand industry's concern with, national defense—as opposed to other darker, more disastrous days—it is only necessary to look at the current effort to produce a satisfactory intercontinental (5,000-mile) ballistic missile and its smaller corollary type, the intermediate range (1,500-mile) missile.

Shortly after the program, tardily, perhaps, for various reasons, was placed on a "crash" basis by the Pentagon, we found briskly working on it, among others, for propulsion, the Aerojet-General Corporation—a division of the General Tire & Rubber Company—and the American Machine & Foundry Company; for nose cones, Avco Manufacturing Corporation and General Electric; and for the guidance systems, among others, American Bosch Arma Corporation, Burroughs Corporation, Remington Rand, the AC Spark Plug Division of General Motors, and Bell Telephone Laboratories.

Direction of the entire technical phase of the problem, in which, of course, many of the leading airframe manufacturers as well as regular Government arsenals are concerned, is under the general supervision of the hustling Los Angeles firm of Ramo-Wooldridge, Inc.

Costly modification, more expensive in terms of time than dollars, which could, of course, always be made available under the exigencies of war, was one of the great dishearteners and abusers of efficiency in World War II in almost every attempt to mesh American production capacity with war needs.

HOWEVER, awareness of the handicap which it always imposes on continuous manufacturing processes, through the lessons learned in World War II, has not been lost. Its acceptance as a situation to be carefully watched and approached with mutual concern by the military and the manufacturers is reflected in the Defense Department's drive today against costly modifications.

A typical incident occurred in rushing through the AN ARC-21 electronic transceiver. The "debugging" step in this development was permitted to get behind, not before, quantity production. There was no excusable reason for this; but the speed with which the error was admitted and corrected by the military augurs well for more orderly procedures in time of actual emergency.

A minor matter, perhaps, but typical of the newer and brighter day of cooperation which has dawned between industry and the national defense.

Air Power Literature

Three principal categories of works dealing with military aviation should be in the airman's library — the early classics which predicted aviation's future, popular volumes which add background, and authentic reference books

Brig. Gen. Dale O. Smith, U.S.A.F.

THE military airman should have a wide and deep background of military history. After all, the conquest of the air has not changed the psychology of mankind. His history of violent conflict is a most revealing and exciting study. New weapons, new knowledge, new customs and beliefs have not materially changed mankind's behavior. And a military man must know what to expect of mankind in all conditions of tension and conflict. Only then can his hunches turn out to be brilliant calculated risks.

But in studying military history he must beware of becoming enmeshed in the military forms at the expense of the military substance. A student could spend his lifetime studying the tactical dispositions of Caesar or Napoleon and learn very little which might be applicable today. Weapons and conditions of war make tactical dispositions, and weapons and conditions are fundamental variables.

ON the other hand, if the student seeks common tactical qualities he can trace them through all the wars of history, finding threads which present new possibilities when applied to modern weapons and conditions.

Take for instance the problem of command, communications, and control. Voice, drums, bugles, flags, whistling arrows, signals, smoke, lights, telephone, radios, radar, and TV have been used. Each has left much to be desired. Communicating commands has always presented a weakness, a possibility of catastrophic error. So tactical dispositions had to take this weakness into account. Dispositions had to be simple in order to be understood. Moreover, it was easier to train for simple dispositions. This provided a reliability and cohesiveness which contributed to victory. Thus we get a principle of war: Simplicity.

The degree of simplicity is decided by subjectively weighing the risks as determined from the commander's extensive study and experience of war. Simplicity is no virtue in and by itself. Simplicity is desirable in order to achieve better communications, discipline, reliability, and training. The commander must assess all this to determine how simple or complex he can make his dispositions. How can he assess such problems without knowledge of historical precedent?

The Department of the Air Force publishes each year a "Professional Reading Guide for Air Force Officers" (AFP 36-5-1). This is compiled at Air University by the Research Studies Institute. The reading guide is a most useful pamphlet, but it covers a much broader scope than will be attempted here. The Guide suggests reading for "a useful background of general knowledge," and hence covers almost every discipline of learning.

The Reading Guide in no way centers specifically upon the military profession, or upon the aviation aspect of that profession, even though many significant air books are listed. Many important military works are omitted, but the most glaring omissions are found in the air-power classics, such as Billy Mitchell's "Winged Defense" and Giulio Douhet's "Command of the Air."

To review literature dealing with military aviation, three categories might be considered: (1) The classics—those few early books which closely predicted the air-power future; (2) Popular volumes which add background knowledge to the profession; (3) Reference books which require lengthy study.

Starting with the classics, let us look at Billy Mitchell's "Winged Defense," (New York: G. P. Putnam's Sons, 1925). It is true that General Mitchell was a dogmatic prophet who wrote off the top of his head. "Winged Defense" reads like a staff study, full of "facts" and assertions. But one must concede that the prophecies made in

General Smith is chief of Policy Division, Directorate of Plans, Deputy Chief of Staff, Operations, Washington, D. C. He is author of the recent book, "U. S. Military Doctrine."

this book proved startlingly accurate.

Take three predictions, for example: First, "the former isolation of the United States is a thing of the past" (p. xi). Mitchell did not predict this on the basis of the political or social climate, for in 1925 we were withdrawing into our shell in every international sense. Billy Mitchell projected the technical development of aviation and saw it bridging oceans and mountains. He saw it compressing time. He saw it spanning the arctic. He saw it eliminating all the technical and geographical conditions which had made our isolation possible. And he clearly saw the threat of air attack which so concerns us today.

Another Mitchell concept that has been repeatedly verified is that "nothing can stop the attack of aircraft except other aircraft" (p. xiv). This may be an overly simplified statement, but if one considers guided missiles and rockets as unmanned aircraft, the statement will probably hold up indefinitely.

In any event, we have yet to see missiles or artillery stopping the attack of aircraft, while the Battle of Britain demonstrated that defending aircraft could make an attack so costly that it had to be discontinued.

A third concept which has made some halting progress since 1925 is that "unity of command is essential to air forces." At least we have a U. S. Air Force, but combat aviation is still parceled out to other services.

ANOTHER of Mitchell's books, "Our Air Force," published in 1921 (New York: E. P. Dutton & Company) had this to say in the foreword: "As a prelude to any engagement of military forces or naval forces, a contest must take place for control of the air. The first battles of any future war will be air battles. The nation winning them is practically certain to win the whole war."

This book gives one of the only professional analyses of U. S. aviation in World War I and makes a number of amazingly accurate predictions throughout.

While on the subject of Mitchell, his better biographers should be mentioned. The best is I. D. Levine who published "Mitchell, Pioneer of Air Power" in 1943 (New York: Duell, Sloan & Pearce, Inc.). Beautifully written and scrupulously accurate, this book is an aviator's "must." It shows a Mitchell who far surpasses the legend: a great warrior—brilliant, energetic, courageous, and patriotic—with varied experiences of hazardous duty, and a perpetual scholar of warfare.

A recent biography and one written with much color and understanding of the Mitchell personality is that of Roger Burlingame, published in 1952 by McGraw-Hill Book Company. Burlingame interviewed members of the Mitchell family and dozens of Mitchell's friends to provide a highly interesting character study.

In the same category is "My Brother Bill" by Ruth Mitchell (Harcourt Brace & Company) who uses a great many personal letters from her brother to provide a vivid picture of General Mitchell's activities and philosophy.

Two other forward thinkers on air power of Mitchell's day were Air Chief Marshall Sir Hugh Trenchard and Giulio Douhet. Unfortunately Trenchard died this year with little of his great wisdom having been committed to writing. A few published speeches and articles are about all that can be found by the average scholar.

But Giulio Douhet wrote the most profound and controversial of all air-power books, "The Command of the Air." The best translation is by Dino Ferrari (Coward-McCann, Inc., 1942) but Louis A. Sigaud's "Douhet and Aërial Warfare" (G. P. Putnam's Sons, 1941) is a well-edited volume containing many pointed observations by the author which adds much to the understanding of Douhet.

This is the first of a series of three articles designed to give the military student a reading guide to books of history, current developments, and reference that will be of value to him in his professional tasks. The present article discusses books of particular interest to the airman. Subsequent articles will list works of especial value to Army and Navy personnel. —THE EDITORS.

ESSENTIALLY, Douhet predicted that offensive air power would become the dominant instrument of war and that land and sea forces would be devoted to defending and supplying air establishments. Many opponents assert that World War II demonstrated Douhet's error, yet few will go so far as to say that World War III won't follow his pattern. True, Douhet's knowledge of bombing effectiveness with TNT was faulty, but since Douhet was an artillery officer and not an airman, one can forgive his lack of knowledge of air ordnance.

In 1942 Alexander P. de Seversky took up the air-power banner, and he has ever since been the most prolific among writers on air matters. "Victory through Air Power" published that year by Simon & Schuster, Inc., was widely read and discussed. With the great air battles just completed and impending, there was little vocal criticism of the air-power doctrine. But the gears of war had already been manufactured for a surface struggle, and air power in its Mitchell-Douhet-De Seversky sense was a latecomer.

The war was nearly over when enough strategic air power had been fashioned to make a significant showing. Major de Seversky's book had much to do with the continued faith in strategic bombardment held by the Allies, which permitted the eventual forging of the huge strategic air forces that hastened the war's end.

Again, in 1950 De Seversky took up the pen and castigated America for its lagging interest and meager understanding of air power. "Air Power: Key to Survival" (Simon & Schuster) was a convincing conceptual evaluation and argument. Although De Seversky's style suffers a bit from his unquenchable enthusiasm and conviction, the validity of his material and the accuracy of his predictions put him in the forefront of air-power philosophers.

Two recent books may well become classics in this field, for they present unique ideas from different points of view. Bonner Feller's "Wings for Peace"

is a brilliantly developed thesis for the exercise of a Western Hemisphere strategy based on air power. This was published in 1953 by Henry Regnery. An opposing view of air-power strategy was developed by Thomas K. Finletter in his "Power and Policy" (Harcourt Brace & Company, 1954) which discusses the use of collective security.

Two books published in 1954 provide important reading in this field. The little-known work of Earl R. McClendon, "Autonomy of the Air Arm," published by Research Studies Institute of Air University, is by all odds the most thorough and factual study of America's drive for a separate air force.

The other, better known, written by a retired R.A.F. Air Marshal, Sir John Slessor, put forth the "atomic stalemate" concept which, however shortsighted, has influenced Western policy to a marked degree because of its hopeful outlook in a foreboding age. This is "Strategy for the West" published in New York by William Morrow & Company.

Broadly speaking, this covers what might be considered air-power classics and related literature. There are innumerable lighter books which throw some illumination on air power and aid in its understanding. Two such, in the polemics arena, were written by William Bradford Huie. In 1942 his "Fight for Air Power" spurred the air-power effort at the beginning of World War II and, along with De Seversky's writings, provided a climate which at least approved of one five-star Air general, Hap Arnold. After the war, in 1946, Huie's "Case against the Admirals" contributed to the effort to unify the armed forces with a coequal Air Force. (Both these books were published by Duell, Sloan & Pearce.)

THE best fiction to present the meaning of air power is "Twelve O'Clock High" by Biernie Lay, himself an Air Force pilot who was shot down in combat. (Harper & Brothers, 1948). A close runner up is "Command Decision" by William Wister Haines, published by Little, Brown & Company in 1947. Still another is "Wake of Glory" by Jack Redding and Thor Smith, published by Bobbs-Merrill Company in 1945. A good fighter yarn written as an autobiography is Robert L. Scott's "God Is My Copilot."

Getting into the reference-book area, there is one on the borderline because of its light style and fascinating content. This is Hap Arnold's "Global Mission" published by Harper & Brothers in 1949. It is an extensive autobiography of one of the world's greatest airmen and merits reading by all other airmen.

Still other biographical accounts need mentioning. "General Kenney Reports" by Gen. George C. Kenney, U.S.A.F. (Ret.), is a frank account of the air war fought in the South Pacific (Duell, Sloan & Pearce, 1949). "Way of a Fighter" by Claire L. Chennault tells a vivid story of the AVG and the Fourteenth Air Force in China which he commanded (G. P. Putnam's Sons, 1949). Sir Arthur "Bomber" Harris published "Bomber Offensive" in 1947 (Macmillan), a splendid account of the R.A.F. effort with considerable strategic theory. Also of interest is Arthur William Tedder's "Air Power" published by Hodder and Stoughton in 1948.

An invaluable reference is "The Army Air Forces in World War II." This massive work in seven volumes was edited by W. F. Craven and J. L. Cates and is a product of the U.S.A.F. Historical Office at Air University. No good one-volume history of the U.S.A.F. in World War II has yet been produced, unfortunately, although Vern Haugland wrote a splendid account of the Pacific air war. His "The AAF against Japan" is a most readable and valuable history (Harper and Brothers, 1948).

A recent book by Gen. Laurence S. Kuter, "Airman at Yalta" (Duell, Sloan & Pearce, 1955) provides an interesting airman's view of one of the most significant conferences of modern times. The struggle of aviation to achieve recognition is brought out here in a new light.

Some valuable works are now being published by former air leaders on the other side of World War II. Gen. Adolph Galland, who commanded German fighters, has produced an excellent volume, "The First and the Last" (Holt, 1954), while two former Japanese air leaders, Masatake Okumiya and Jiro Horikoski have, under the able editorship of Martin Caiden, come out with "Zero!" (Dutton, 1956).

THE airman should have some grasp of the early history of aviation if he is to round out his professional education. The best biography of the Wright Brothers, and the only one authorized by Orville Wright himself, is written by Fred C. Kelly, "The Wright Brothers" (Farrar, Straus & Young). This is a frank and accurate account backed up by exhaustive research of original source material. Kelly also edited significant correspondence and published it under the title "Miracle at Kitty Hawk" in 1951 (Farrar, Straus & Young).

The most complete collection yet made of the Wright material is "The Papers of Wilbur and Orville Wright," edited by Marvin W. MacFarland. It is in two large volumes and was published by McGraw-Hill Book Company in 1953.

Perhaps the best source of original data on the effects of air power in war is the Franklin D'Olier report of the U. S. Strategic Bombing survey made shortly after the end of World War II by a group of objective experts appointed by President Roosevelt. Three specific volumes of this voluminous report should be studied by every airman: "Over-all Report, European War," "Air Campaigns of the Pacific War," and "Summary Report, Pacific War." These reports can be obtained from the U. S. Government Printing Office.

A valuable technical analysis of air power was made by Stefan T. Possony in 1949. His "Strategic Airpower" was published by the Infantry Journal Press.

This review of air-power literature is far from inclusive, yet space prevents listing all the valuable publications available. One thing that strikes the adventurer in this literary field, however, is the realization that air-power literature is so meager.

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Ordnance Day 1956

The Honest John Rocket blasts off

ALL-WEATHER ordnance equipment manned by all-weather soldiers was displayed to an all-weather A.O.A. crowd at Aberdeen Proving Ground on October 4, 1956. Steady rain all forenoon failed to dampen the interest of over 4,000 members who witnessed tests and demonstrations of the Army's modern firepower.

The meeting was opened by Maj. Gen. C. H. Deitrick, commanding general, Aberdeen Proving Ground, who introduced Vice Adm. George F. Hussey, Jr., president of the American Ordnance Association, who in turn welcomed the members and thanked Army Ordnance for its hospitality.

Lieut. Gen. E. L. Cummings, Chief of Army Ordnance, and Assistant Secretary of the Army Frank H. Higgins also made brief addresses.

Secretary of the Army Wilber M. Brucker opened the afternoon session with an address praising the American Ordnance Association, Army Ordnance, and the men of industry for their outstanding coöperation in developing and producing the Army's weapons. At the conclusion of the demonstrations Gen. Maxwell D. Taylor, Chief of Staff of the Army, closed the program with compliments for the splendid performance of men and matériel throughout the day.

On the demonstration front the members watched many of the Army's weapons go through their paces in maneuvering and firing. Of especial interest were nine new weapons, previously classified, that were demonstrated to the public for the first time. These weapons are described below:

7.62-mm. Machine Gun T161E3—a lightweight general-purpose machine gun developed to replace all three of the present U. S. Army caliber .30 machine guns.

20-mm. Aircraft Machine Gun M39—a relatively light-weight, electrically fired, gas-operated gun with a high firing rate made possible by the 5-chamber, revolver-type cylinder.

30-mm. Aircraft Machine Gun T182—A heavier revolver-type weapon, similar to the M39.

20-mm. Gun T171 (Vulcan)—specifically designed for present supersonic jet aircraft, with its rotating multibarreled cluster borrowed from the original Gatling gun.

175-mm. Gun T45—the newest and one of the most versatile field-artillery pieces. Superior to all World War II artillery in its flexibility, it unlimbered and went into firing position quickly.

105-mm. Mortar T33E3—a smoothbore weapon having greater range and improved accuracy over the preceding models although lighter in weight.

90-mm. Gun Tank M48E1—It mounts the first effective fire-control which permits accurate fire while in motion.

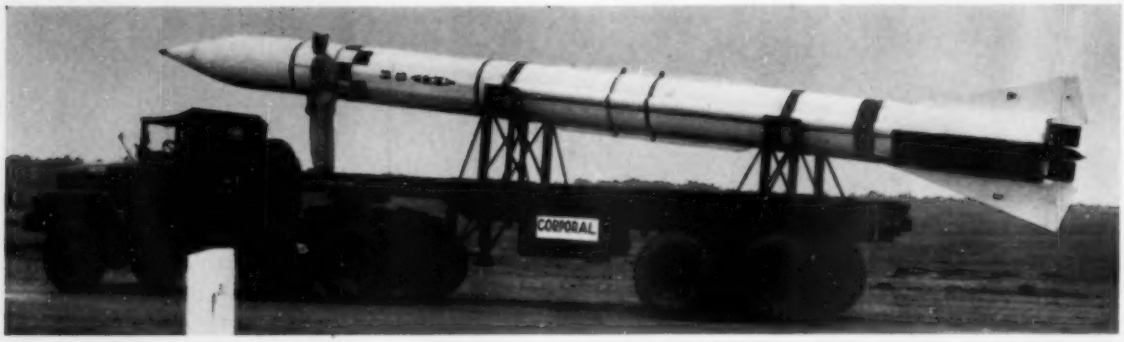
Dart Guided Missile—a 5-foot antitank missile that showed its great accuracy by striking a moving target at 2,100 yards.

318-mm. Little John Rocket XM47—a small-caliber field-artillery free rocket approximately 12 feet long.

Maj. Gen. J. B. Medaris, commanding general, Army Ballistic Missile Agency, described the salient features of the Redstone guided missile. (All the illustrations on the accompanying pages are from Army photos.)

More than 4,000 A.O.A. members, above, watch demonstration of the Nike anti-aircraft missile. Below, Maj. Gen. C. H. Deitrick, Aberdeen commander, left; Hon. Wilber M. Brucker, Secretary of the Army; and Lieut. Gen. E. L. Cummings, Chief of Ordnance of the Army, right, observe one of the tests.

The newly disclosed 175-mm. gun, below, features mobility, rapid emplacement, and long range. It fires a 150-pound shell. The huge Redstone ballistic missile, right, is shown being emplaced on its launching stand. It is a surface-to-surface, liquid-fueled weapon with a self-contained guidance system.



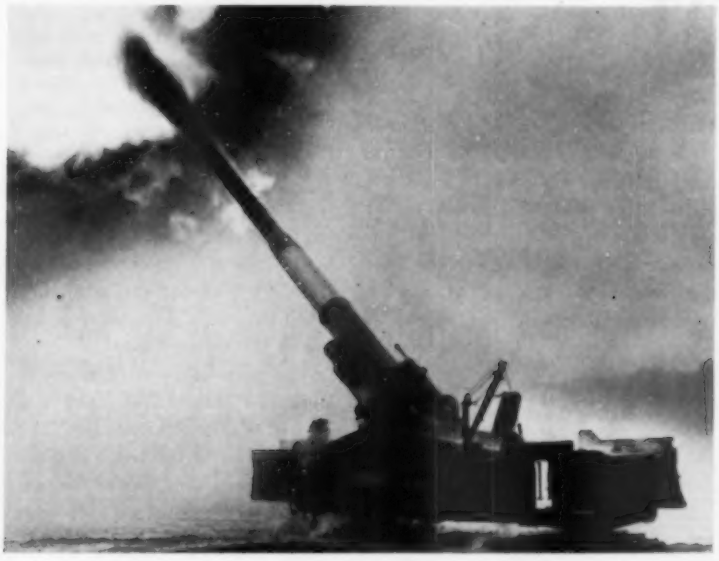
The Corporal XSSM-17 guided missile, above, is a surface-to-surface, liquid-fueled, artillery-type weapon 45 feet long, weighing 6 tons. The missile is launched vertically and then tilted toward its target for an undisturbed ballistic flight. The Corporal can be transported on a mobile launcher and put into action quickly against an enemy.

The Dart XSSM-A-23 antitank guided missile, above, was shown to A.O.A. members for the first time. It carries a shaped-charge warhead and can defeat any known tank armor. The Dart smashed the target, left, mounted on the 120-mm. gun tank M103 at a range of 2,100 yards.

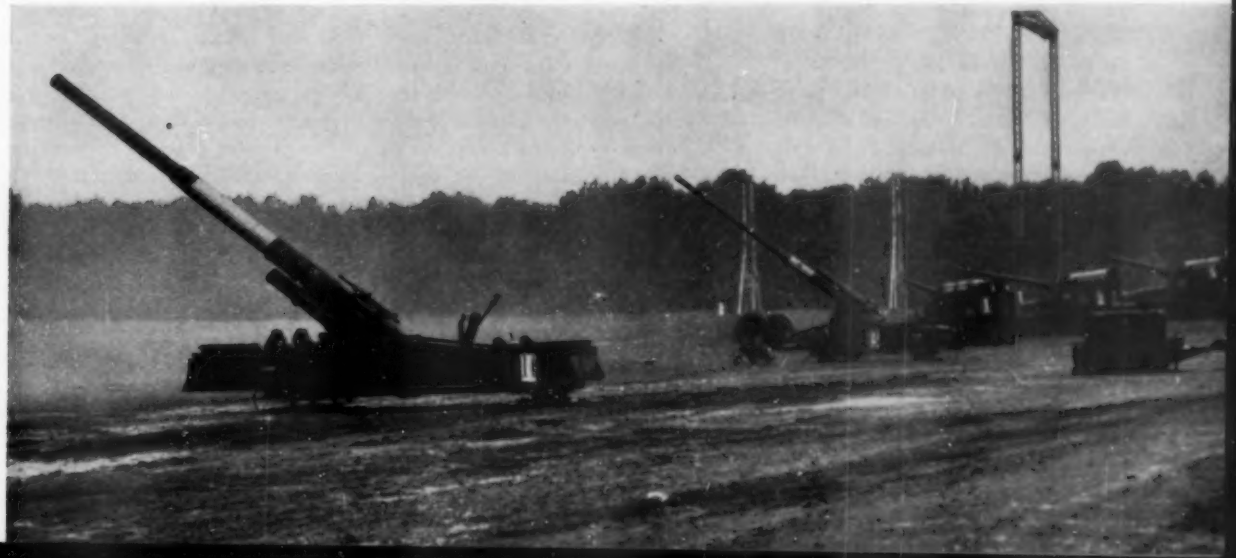
The infantry light weapons carrier XM274, right, is a lightweight, low-silhouette vehicle intended primarily for use in forward combat areas to transport crew-served weapons and ammunition. Known as the Mechanical Mule, it is powered by an opposed-cylinder engine. It weighs 830 pounds and can carry a payload of 800 pounds. The steering wheel can be swung downward so that the driver can operate the vehicle from a crawling position if necessary. It is shown here carrying the 106-mm. recoilless rifle M40A1, known as the BAT.

Displays and exhibts at the 38th Annual Meeting included vehicles, instrumentation, coatings and chemical materials, standardization, armament, and foreign matériel. The Signal Corps exhibit is shown above while the Ordnance display was housed in the huge plastic "bubble" in the background which was kept inflated by positive air pressure.

The new 7.62-mm. general-purpose machine gun T161, above, will replace the caliber .30 weapon.



Above, the 280-mm. "atomic" gun T131 fires. Below, left to right, are the 280-mm.; the 175-mm. gun T145; the M44 self-propelled 155-mm. howitzer; the M53 self-propelled 155-mm. gun; and the M55 self-propelled 8-inch howitzer.



Metallurgy of Titanium

The affinity of titanium for oxygen, nitrogen, carbon, and iron and the large scrap loss in handling make for difficult production problems which must be solved if the metal is to be produced economically

Marion G. Mastin

MANY articles have appeared during the last few years about the new metal, titanium—its potential abundance, its unique properties, its position as a material of construction and its probable place in defense equipment. Not so much has been written about how it is produced or about the reasons for its high cost.

Titanium has been known for more than a century and a half. It was discovered by Gregor in 1791, named by Klaproth in 1795, and was prepared in small amounts by others during the succeeding century. It remained for Wilhelm Kroll to discover a method for the preparation of titanium sufficiently ductile to be useful. His United States patent application was filed in July 1938.

The same year, the United States Bureau of Mines decided to investigate the possibility of commercial production of titanium, assigning Frank Wartman to the project. In the late 1940's, Wartman had succeeded in producing the metal in batches of about 125 pounds each, and had found ways of avoiding the many process difficulties. Then Du Pont, after studying Wartman's methods, began the world's first commercial production of the metal in 1948 in a small plant rated at one hundred pounds a day.

A great deal of research on other methods for the production of titanium has since been done, but the fact remains that the Kroll process as perfected by Wartman and as modified in detail by others is the only process in use in this country today.

Mr. Mastin designed and operated the Bureau of Mines experimental titanium pilot plant at Boulder City, Nev., and has since served as consultant to the titanium industry here and abroad.

The principal ores of titanium are rutile, the oxide (TiO_2) and ilmenite, an iron titanate (theoretically $TiFeO_3$). No one has yet succeeded in obtaining ductile metal from any of the ores. Instead, the ore must be chlorinated at about 800 degrees centigrade in the presence of enough carbon to combine with the liberated oxygen to produce titanium tetrachloride ($TiCl_4$).

This product is a heavy, colorless liquid which must be kept in tightly closed containers because it reacts with the moisture in the air to produce hydrochloric acid and a dense fog of a hydrated titanium oxide and oxychloride. It has been used extensively in wartime as a smoke screen and is also a raw material for the production of titanium pigments as well as for titanium metal.

The tetrachloride so made is reduced at red heat by metallic magnesium as in the Kroll process, or by metallic sodium at temperatures above 200 degrees centigrade by those who prefer sodium to magnesium. One British company is now using sodium and one American firm is currently erecting a plant in Ohio which will employ sodium.

Before describing the process in more detail, it may be helpful to discuss some of the difficulties to be overcome. To be useful, titanium must not be hard or brittle. Small amounts of oxygen or nitrogen, as well as iron and carbon, make the metal so hard as to be useless.

CURRENT specifications call for not more than 0.1 per cent oxygen, 0.03 per cent nitrogen, 0.15 per cent iron, and 0.05 per cent carbon. Yet the metal when hot readily picks up any of these impurities to which it may be exposed, and there is no known practical method for their removal if picked up.

Another difficulty is the fact that the metal reacts with and decomposes any known refractory material, absorbing oxygen in ruinous amounts as a result.

This problem is solved by handling titanium during its manufacture in vessels of mild steel at about 800 degrees centigrade, or at a temperature low enough to keep alloying with the steel at a low level, although any titanium metal in direct contact with the steel will contain too much iron to meet specifications and must be discarded.

To make ductile metal then, we must reduce and purify at high temperatures in such a way as to exclude access at all times to air, moisture, and other harmful impurities, using the most highly purified tetrachloride obtainable and high-grade magnesium or sodium.

The Kroll-Wartman process is conducted as follows, it being understood that every producer has made minor modifications to suit his own conditions:

Magnesium ingots, usually weighing twenty pounds each, are pickled in dilute acid to remove surface oxidation and are then rinsed, dried, and inspected for cleanliness. To make a 250-pound batch of titanium, 280 to 285 pounds of cleaned ingots are placed in a cylindrical, flat-bottomed steel pot. The pot cover is placed in position and the joint is closed by welding a bead all around, care being taken to avoid as much penetration as possible.

The closed pot is then tested for tightness and is not used until the absence of leaks is assured. All air is removed from the pot by evacuating twice, releasing the vacuum each time with pure helium or argon. Inert gas pressure is left on the pot until it is ready to use.

The pot and its charge of magnesium are placed in a vertical cylindrical furnace, heated by electricity or burning fuel, and equipped to maintain any set temperature as desired. Heating is begun, and after about 1½ hours some of the magnesium will have begun to melt and the feeding of purified titanium tetrachloride at controlled rates may be started while still maintaining an inert gas pressure on the reaction vessel to prevent any inward air leakage.

THE reduction reaction is highly exothermic so that tetrachloride is fed at a rate which will not generate more heat in the vessel than can be dissipated through its walls, no furnace heat being used during this period. Vessel temperature is maintained at not less than 750 degrees centigrade nor more than 1,000 degrees.

The actual reaction mechanism is probably quite complex, but the net result is as follows:

$TiCl_4 + 2\,Mg = Ti + 2MgCl_2 + \text{heat}$

or, 4 pounds of tetrachloride reacts with 1 pound of magnesium to produce 1 pound of titanium plus 4 pounds of magnesium chloride, approximately.

In practice, excess magnesium must be maintained at all times to prevent side reactions, so that magnesium efficiency will not usually be higher than 90 per cent. The by-product magnesium chloride is tapped from the pot in molten form from time to time during the reaction period and drained as completely as practical after the reaction is completed, taking care to admit no air at the taphole.

The pot with its contents is removed from the furnace as soon as it has cooled sufficiently to have lost all color. After removal from the furnace it is allowed to cool another twenty-four hours to make sure that the contents are at room temperature. A small positive pressure of inert gas is maintained at all times.

When ready to open, the vessel is placed on a slowly revolving table, and the bead weld which sealed the cover to the pot is removed by a swing grinding wheel such as is used to clean castings in a foundry. When the bead is removed, the pot is taken to the dry room to be opened.

The reduction mass is a mixture of titanium, magnesium, and magnesium chloride, and since the latter is hygroscopic it will pick up moisture if exposed to ordinary air. During the subsequent heating in the purification step, any moisture so absorbed would contribute its oxygen to the titanium. The pot contents must therefore never be exposed to moist air.

A dry room is provided in which the pot is opened, the reaction mass removed, a new charge of clean magnesium placed, and the pot closed. The air in the dry room is maintained at a humidity corresponding to a dewpoint of at least minus 40 degrees centigrade (0.55-grain of moisture per pound of dry air or 0.006-pound per thousand cubic feet of air at 70 degrees Fahrenheit), usually by passing it continuously over beds of activated alumina in standard equipment.

When the lid is removed from the pot in the dry room, the pot is found to be about half full of a spongy mass of titanium whose pores are filled with solid magnesium chloride plus the unused excess of magnesium. The composition of the mixture averages approximately:

250 pounds of titanium in sponge form, 100 pounds of magnesium chloride, and 35 pounds of magnesium.

This crude titanium must be purified by the practically complete removal of the magnesium chloride and magnesium, a step preferably performed by distilling off these impurities at red heat under greatly reduced pressure.

THE pot is chucked in a lathe and the contents are turned out in chips of less than half an inch in size. They are received in the steel "basket" in which they will be distilled.

Care is taken to leave half an inch of reaction mass on the side walls and bottom of the pot throughout the life of the vessel in order to confine the major part of the contamination with iron from the vessel itself to this portion.

The turning operation is conducted as rapidly as possible and the pot is removed from the lathe, charged with magnesium, and closed without loss of time to minimize moisture pick-up. The basket of chips is placed in a clean retort which is immediately sealed and evacuated.

Evacuation to a pressure of about 40 microns (about 1/20,000 of an atmosphere) is obtained with a mechanical pump and continued for several hours to remove as much absorbed air as possible from the retort and contents. The retort is then placed in an electrically heated vacuum furnace so arranged that the pressure in the furnace outside the retort is approximately the same as the pressure inside the retort. If this were not done, the retort would collapse at the temperature employed during distillation—about 930 degrees centigrade.

The retort is a steel vessel thirty inches in diameter by eight feet high,

with half-inch walls. The lower five feet are placed in the furnace—the retort being carried by a flange placed at this point. The upper portion of the retort is water-jacketed and thus serves as a condenser for the impurities distilled from the hot chips. The magnesium and magnesium chloride condense in heavy layers on the cold steel surfaces provided in the upper area, and are then easily removed when the operation is completed.

Distillation is continued under vacuum for about thirty hours to remove a maximum of impurities. At the end of this time the vacuum in the retort is released with inert gas simultaneously with the release of the vacuum in the furnace with air.

AFTER the water and vacuum connections are broken, the retort is removed from the furnace and placed in a cooling stand to cool for at least 24 hours. Cooling water is kept on the jacket and a small pressure of inert gas on the retort until cooling is completed.

The retort is then opened and the contents removed. The purified titanium sponge is chipped from the basket, having sintered together during the distillation, and is passed through a crusher and sized over screens to provide a product meeting the buyer's size specifications. The demand is usually for all minus ⅜-inch or ½-inch plus 20 or 30 mesh. About ninety-seven per cent of the sponge produced will meet this requirement.

The retort, basket, and all internal condensing surfaces must then be thoroughly cleaned to remove all magnesium, magnesium chloride, and any rust or scale.

AN alternative method of sponge purification is to leach the impurities with an acid solution, preferably nitric acid with or without additives. While this method produces a product adequate to today's specifications, there is little doubt that vacuum distillation will produce sponge of measurably lower hardness than leaching.

The proponents of the leach method claim to be able to purify at lower costs, and they cite the much smaller cost of leach equipment compared with electric vacuum furnaces and vacuum pumps. It is true that the latter are expensive, but their life is long and operating and maintenance costs are very low.

Vacuum-distillation equipment costs less than $500 per ton-year capacity installed and may be amortized in 10 years at $0.0225 per pound of titanium. Power required for the furnaces and vacuum pumps is not more than 3 k.w.h. or, at 7.5 mills per k.w.h., about $0.0225 more per pound. These two items, plus maintenance, add up to a distillation cost of close to $0.05 per pound of product before operating labor—a small figure. This is believed to be less than the cost of leach materials alone without taking into account any of the other costs of the leaching process.

While titanium tetrachloride is the principal raw material from which titanium may be produced directly be-

cause of its low cost and ease of purification, magnesium is only one of the two competing reducing agents. Metallic sodium is readily obtainable in a highly purified state and at a cost equal to or slightly less than that of magnesium on a use basis.

Sodium yields by-product common salt which has an advantage over magnesium chloride in that it is not hygroscopic. Again, magnesium will not react well with tetrachloride much below 750 degrees centigrade while sodium will react at 200 degrees. This gives the operator a wider choice of reduction conditions.

Sodium is at a disadvantage because of the greater hazard in handling and because its heat of reaction with tetrachloride is much higher than when using magnesium. Since the rate of production of sponge is controlled to a large extent by the ability to dissipate the heat of reaction in order to avoid overheating, this becomes an important factor.

All companies currently using sodium, or proposing to base their processes on sodium, employ the leach method of purification. This is much safer procedure than in the case of reducing titanium by magnesium and, in addition, leaching with water only is feasible and satisfactory.

NO matter how it is made, the sponge must be melted into an ingot before it can be rolled, forged, or extruded. The melter thoroughly mixes his sponge with or without alloying ingredients and presses it into long bars about two inches or more square. These bars are used as consumable electrodes in the arc-melting of the metal in a vacuum in a water-cooled copper crucible the size and shape of the desired ingot.

There are two principal reasons for the high cost of today's titanium mill products—sheet, plate, rod, tubing, wire, etc. The first of these is the current cost of Grade A sponge—$3.45 a pound. The second is the large scrap loss in handling from ingot to final product.

THE price of sponge will take care of itself in time, as it is now known that production costs after plant amortization, and after reaching a realistic cost of production of titanium tetrachloride, will fall to a figure of about $1 a pound, even if no better process than Kroll's is found.

Scrap loss is another matter. Scrap is derived from many sources. Ingots must be reduced about one inch in diameter in a lathe to eliminate surface roughnesses before rolling. Ends must be cropped. Billet ends and trimmings from plate and sheet are accumulated. Some shapes must be machine-surfaced before furthers reduction, etc.

All such products have more or less surface oxidation, depending to some extent on how high they have been heated. Remelting oxidized material means a sharp increase in hardness, and there is no known, practical way to remove surface oxidation other than by machining, which in many cases is impossible.

Despite these handicaps, the percentage of scrap loss is being reduced month by month. In the author's opinion, when sponge can be produced for $1, mill products will be available for $3 to $5. When this time arrives, titanium will have come into its own.

Admiral Arleigh A. Burke, U.S.N.

Chief of Naval Operations

will be the honor guest and

principal speaker

at the

Annual Industrial Preparedness Dinner Meeting

of the

American Ordnance Association

to be held under the auspices of

The New York Post of the Association

in the

Grand Ballroom of the Waldorf-Astoria

New York City

Wednesday, December 5, 1956, at 7:30 p.m.

Black tie *Guests may be brought*

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At 9:30 a.m. and again at 2:30 p.m. on the Starlight Roof of the Waldorf there will be panel discussions on New Technological Developments in American Armament in Metallurgy, Electronics, Instrumentation, and Propulsion. Each panel of civilian and military experts will be led by an outstanding industrialist or scientist. Luncheon on the Starlight Roof will be addressed by Maj. Gen. J. B. Medaris, Commanding General, Army Ballistic Missile Agency.

Reservation forms may be obtained from A.O.A. headquarters in Washington. Reservations will be accepted until Wednesday, November 21st, if seating space still permits. All surplus of receipts over expenditures connected with the meeting will be donated to the Navy Relief Society.

Civil War Artillery

The Battle of Gettysburg was a high point in the development of smoothbores and rifled cannon and their ammunition, proving the need for good logistics and the important rôle of the mobile big guns in both attack and defense

Eugene B. Canfield

"IF you are coming at all you must come at once or I cannot give you proper support; but the enemy's fire has not slackened at all. . . ." So wrote the Confederate artillerist, E. P. Alexander, to General Pickett about half an hour after the artillery firing had commenced, opening the battle on the third day at Gettysburg.

Yet three quarters of an hour later Union General Howard, posted with his XI Corps on Cemetery Hill, about 1,100 yards from the Confederate artillery, was able to report that he had suffered little damage: "The batteries on our right do not reach us, and in center invariably overshoot us."

True, Cushing's and other batteries at "The Angle" suffered, but what kind of guns were these that could elicit such comments from two opposing officers in the midst of one of the greatest artillery duels the world had yet seen?

VOLUMES have been written on the Civil War from Henry's "The Story of the Confederacy" to Bigelow's study of the battle of Chancellorsville. In them we read of the rebel yell, one general's competence, another general's trouble with raw recruits, one regiment's ability to stand up under the "withering fire of the enemy" while another near by retreats in confusion. Battlefield tactics are described and the outcome of a battle is related to these events.

Mr. Canfield is a student of ordnance history. His present interest in artillery development began as a result of his work as a development engineer for General Electric Company, Schenectady, N. Y., where he has been active in devising armament systems for today's modern artillery.

Yet where do we learn the capabilities of the weapons, those tangibles around which battlefield tactics are formed and which, with the tactics, change from war to war? Under the scope on which most histories are written, it is difficult for the reader to determine if the statements of Alexander and Howard express a more or less expected incident under the particular circumstances, or whether the incident is most unusual and out of the ordinary.

In short, most of us do not have a conception of whether or not a 2,000-yard distant target was a difficult or an easy one for a Civil War gun. To cover the complete scope of Civil War arms would be next to impossible. However, it is hoped this venture will provide a better insight to those interested in the problems of Civil War artillery.

On the field at Gettysburg were emplaced 415 guns, of which 182 were Confederate and 233 Union. Although 60 per cent of the Union guns were rifles, while the Confederates had 50 per cent rifles, the artillery of both antagonists was made up primarily of three types of guns: 12-pounder smoothbores (Napoleons), 10-pounder Parrott rifles, and 3-inch ordnance rifles. Earlier in the war the 6-pounder smoothbore also had seen service, but it was gradually replaced as the rifles and heavier smoothbores became available.

ALTHOUGH the Tredegar Iron Works of Richmond, and a few others, were able to cast cannon for the Confederacy, they never could keep up with the demand. Consequently it was left to the Union forces to supply that demand, an operation they performed rather well, for of the 101 artillery pieces captured by Sheridan in the Shenandoah Valley campaign of 1864, 80 originally had been cast for Union forces.

For the smoothbore guns there were primarily four kinds of projectile: solid shot, shells, spherical case, and canister. To facilitate muzzle loading and also to take care of manufacturing tolerances, there was a difference in the diameter of the bore and projectile (called true windage) of 0.1-inch for a 12-pounder. Consequently, in firing a smoothbore, much of the pressure of the gases was lost due to the lack of a good seal within the bore.

A rifled 10-pounder, having a good seal, used only one pound of powder to propel its shot, while the 12-pounder

smoothbore required 2½ pounds of powder.

Shells were hollow shot filled with powder and set to burst at the appropriate time by means of a fuze. They were less accurate than solid shot but produced considerable moral effect and were especially useful against cavalry. A 12-pounder shell weighing a little over 8 pounds and filled with 7 ounces of powder would burst into 12 to 15 pieces.

SPHERICAL case shot or shrapnel were similar to shells, except the walls of the shot were thinner and the interior was filled, in the case of the 12-pounder, with 4½ ounces of powder and 78 musket balls. According to Gibbon, range was effective to about 800 yards.

Canister consisted of a number of cast-iron balls, usually 27, one-third the diameter of the bore and packed with sawdust into a tin cylinder to facilitate loading into the piece. It was truly the dismay of the infantry, and was effective up to 600 yards, although best results were obtained at about 300 yards.

A large percentage of the casualties in Pickett's charge were undoubtedly caused by canister, the Union guns being double-shotted. Throwing canister represented one of the few cases where smoothbores outshone the rifles, since the rifles, for an equivalent weight shot, had a much smaller bore and could not hold as many balls.

The standard fuze for field artillery service, the Bormaun fuze, was far superior to the old wooden tube fuzes which had to be cut to length and inserted in the shell at the time of firing. It consisted of a small metallic disk which could be screwed into the shell at any time previous to battle.

Inside the disk was a time ring of powder composition protected from moisture or accidental ignition by a thin metal covering. Over this ring the metal covering was marked in seconds. To set the fuze, the gunner merely had to cut the metal at the proper time mark with his fuze gouge, thus exposing the time ring to the powder blast of the gun.

The ring burned until it communicated its fire to a small magazine in the center of the disk. The powder in this magazine then blew through the bottom of the fuze and ignited the bursting charge within the shell. Maximum time marked on the fuze was 5¼ seconds, and agreed well with the time required for a 12-pounder shell to reach its maximum range of 1,300 yards.

The only problem with the fuze was that it sometimes failed to ignite, and in almost any battlefield museum an unexploded shell may be found on display, its fuze still intact. Indeed, at the siege of Vicksburg, the Confederate gunners spent much time chasing and retrieving dud Yankee shells for reuse.

In our present day of technological advancement, when radar is outperforming our high-precision optical range finders, it is hard to realize that, with the exception of a few crude stadia, the Civil War artillerist had no rangefinder other than his own good judgment. Of course, ranges were such that the effects of fire often could be observed, and the shells sometimes could be seen in the air without too much difficulty.

Nevertheless, this wasn't as much help as it might seem at first, for the gunner could not go over to the gun and make a slight readjustment in bearing or elevation. Instead, since his gun had recoiled from two to five or more yards, he had to start in all over again and a small fraction of a second error in setting the fuze, or a slight nonuniformity in its burning, could make an otherwise well-aimed shell completely ineffective. The miracle is that artillery fire was as effective as it was.

THE first rifled field artillery guns to see service in the Civil War were the invention of Robert C. Parrott and were constructed at his West Point foundry. They were cast-iron muzzle-loaders, the thickness of metal around the breech being about one caliber. In addition, a wrought-iron jacket about one-half caliber in thickness was shrunk over the breech. Despite all this work, the price of a 10-pounder was only

One of the heaviest guns at Gettysburg, a 20-pounder Parrott in position along the Confederate lines.

Intended to supersede the 10-pounder Parrott, the 3-inch muzzle-loading ordnance rifle was used for more than thirty years after the Civil War.

$187, and weighed less than three-fourths that of a Napoleon. Yet its maximum range was 5,000 yards compared with the Napoleon's 1,300.

This, however, does not mean that the gun was effective at 5,000 yards under battle conditions, for there were still the not inconsiderable problems of aiming and setting fuze time. Furthermore, although the dispersion was less than that of the smoothbore, it was still quite considerable at long range, and occasionally the shells would not take the rifling properly, and would tumble end over end, thus completely destroying their accuracy.

The predominant projectiles used in rifles were shells, case shot or shrapnel, and, of course, canister, although the canister, as before mentioned, was not as effective as that from a smoothbore throwing an equivalent weight shot. Methods of imparting the rifle motion to the projectile were many and varied, permitting ease in muzzle loading yet providing some scheme of expanding a ring of metal into the rifle grooves on firing.

The projectile invented by Parrott for use in his guns consisted of a cast-iron body recessed at the base to receive a brass ring which was cast into place. On firing, the gases would force their way between the brass and the iron and expand the ring into the grooves. This projectile went through several modifications as the war progressed, and so may be seen in several differing forms.

Used for long-range fire against attacking Union troops, a breech-loading Whitworth stands at Gettysburg just as it did in July of 1863.

James' projectile had a large hollow in its base permitting the gases to enter and press the composition paper, canvas, and lead wall into the rifling. It was originally developed for use with old smoothbores which had been rebored and rifled (James' rifles), and weighed exactly twice that of the original smoothbore shot.

One of the most successful projectiles was the Hotchkiss. It consisted of a body, the base of which was smaller in diameter than the top. Over the bottom of the base a cast-iron cap was placed, and a ring of lead occupied the space between the cap and the wide part of the body.

When the charge in the gun was released, the cap was pushed forward on the body, squeezing the lead out into the rifling. In addition to its destructive effect, the Hotchkiss shell produced considerable moral effect and had the reputation of being able to make even the most battlewise veteran duck for cover, for a ragged edge of lead which remained on the shell in flight produced a tremendous earsplitting scream.

THE 3-inch rifle which finally superseded the Parrott 10-pounder for field service was not particularly unlike the Parrott in either weight or ballistic characteristics, although it was made entirely of wrought iron, had slightly different rifling, and a 1/10-inch larger bore. These two guns continued to be used side by side throughout the war.

A little off the road and sheltered by a stone wall along Gettysburg's Seminary Ridge stand two unimposing but rather long barreled guns. Passed over and unseen by most visitors (few even bother to tour the Confederate works unless taken by a guide), closer inspection would reveal them to be breechloaders.

These are the famous English Whitworths, two more of which can be seen northwest of the town. Enjoying the highest prestige regarding their great accuracy and long range, they were complete failures as field guns. The size of projectile was so long and narrow that shell or case shot could not be produced, and only 12-pound bolts or solid shot were available.

The breech mechanism also was

delicate for the times, requiring considerable care, and rough handling in the field could cause it to jam.

The guns were made of wrought iron, and, instead of being rifled in the usual sense, the bore was cut in the shape of a hexagon twisted to produce the rifle motion. This meant that the user had a considerable supply problem, for the hexagonal projectiles were made only in England.

Their first use appears to have been against Fort Sumter where they would have succeeded in opening a breach had not the supply of ammunition run out.

It is usually thought that only the Confederates had these field guns. However, at the beginning of the war a 6-gun battery was purchased by Yankees abroad and shipped over to the United States as a gift. Being considered too delicate for field service, they were never used except on special occasions, although two did find their way into the Federal works before Yorktown where they were to be used especially for dismounting the enemy's pieces.

WITH the exception of the bombardment of Fort Sumter and the siege of Petersburg, the service of heavy artillery is little heard from—and perhaps this is logical, for most of the heavy artillery regiments were stationed in the forts around Washington.

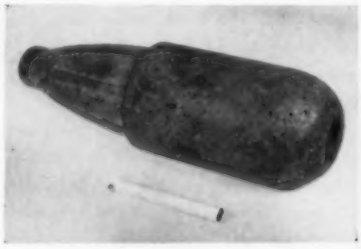
The types of guns used by the heavy artillery were many and varied, but the predominant types were the James, Rodman, Dahlgren, and Parrott.

The James, already mentioned, were old smoothbores, rebored and rifled, throwing a projectile twice the weight of the original smoothbore shot. Thus a 32-pounder smoothbore, when reworked became a 64-pounder rifle. Although the James rifles performed well against Fort Pulaski, reworked smoothbores generally proved to be of low endurance, and their manufacture was eventually discontinued.

In fact, low endurance was the major problem to be overcome in all the large guns of over 6-inch caliber. Being made almost exclusively of cast iron, guns of all types were very unpredictable and would burst without warning almost anytime in their life span. The general definition of a good gun was one that would last 1,000 rounds; yet of the guns of the same kind, all having passed proof firing, one might burst after 5 rounds, another after 200, and a third might not burst at all.

Above, Hotchkiss shell. Lead band between base cap and main body which enabled shell to take the rifling has been lost. Below, shell and grape for 12-pounder smoothbore. Grapeshot was used much as canister but was constructed differently with fewer but larger balls.

Below, Schenkle's projectile. When fired, a papier mâché ring was forced forward on cone-shaped base and expanded into rifling. In dampness, ring swelled so that projectile would not enter gun. South Boston Foundry furnished some 400,000 such projectiles plus very satisfactory fuzes to Federal troops throughout the Civil War.



Canister shot like this, below, was greatly responsible for the repulse of Pickett's charge. All photos courtesy Gettysburg National Military Park.

The usual solution to the problem was to increase the thickness of metal around the breech and then hope that the gun wouldn't burst—this in spite of the fact, not then known, that a thickness of one caliber at the breech would produce 84 per cent of the strength of a breech with infinite thickness of metal.

One of the men who did a great deal to improve the quality of heavy artillery, and perhaps brought the smoothbore to its highest state of development, was Gen. T. J. Rodman of the Ordnance Department.

On duty superintending the manufacture of 8-inch guns at the Fort Pitt foundry in 1845, Rodman noticed that when the castings cooled the exterior metal became solid first, and as the metal continued to contract and solidify, large cracks might be left in the center. These cracks were usually removed when the gun was bored out, and Rodman probably was not the first to notice them.

However, the recent bursting of a large gun, the "Peacemaker," set him thinking, and he came to the correct conclusion that the metal around the outside of the gun was in a state of compression, while that in the center, immediately surrounding the bore, was in a state of tension.

SINCE the explosion of the powder also would create a force of tension around the bore, guns cast in this manner would be subject to failure, and it was Rodman's desire to reverse the order of the internal stresses. Then a gun would be able to withstand the firing of a much larger charge before it was stressed beyond its limit of endurance.

After some investigation into the possibility of wrapping a gun with wire, it occurred to Rodman, "that if we could cool a cast-iron gun from the inside, we could accomplish the same thing. By causing the innermost layer

to cool first, then cool the next layer and shrink it on, as you would shrink tires on wheels, the shrinkage would be from the exterior to the interior. . . ."

RODMAN offered his method to the Ordnance Department several times between 1845 and 1847, and upon a final refusal secured permission to develop and patent his method through private enterprise. The department seemed glad to get him out of its hair, and no guns were cast in this manner for the Government until 1859 or 1860. The final result, however, was that Rodman and Knap each received half a cent for every pound of metal cast under their patent, and by the end of the war most of the large guns, even Dahlgrens and Parrotts, were so cast.

By 1864 the heavy columbiads, used for siege and coastal defense, and mounted in forts like Sumter, were redesigned and cast on the Rodman plan and created some squabble, for the shape, at least, seemed to interfere with the Dahlgren patent.

Rear Adm. John A. Dahlgren was the inventor of the shell gun used widely throughout the Navy. The usual size was 9- or 11-inch, weighing respectively 9,200 and 15,900 pounds, and the manufacturing process necessitated starting with a solid iron casting about twice the weight of the final gun. The casting was then turned down and bored out, and was shaped a little like a beer bottle, having a large heavy breech tapering suddenly to the muzzle.

THE Dahlgren, like the Rodman and columbiad, was a smoothbore. In the Navy, rifles were received with less enthusiasm then elsewhere, for the Navy had a special problem—the roll of the ship. Aiming was thus made difficult, and for long-range firing (anything beyond point-blank range) the gun was elevated only slightly, the shot being made to ricochet across the water and into the target. Since shells from rifles would ricochet at crazy angles due to their spin, they weren't very desirable. And at close range the rifle wasn't markedly superior, for the smoothbore had a higher muzzle velocity.

Practically all the heavy rifles made for both the Army and Navy were the product of Parrott's West Point foundry and were constructed along the same lines as previously described for field guns. However due to the serious problem of bursting, the 100-, 200-, and 300-pounder guns were cast on the Rodman plan, as well as having the wrought-iron cylinder shrunk over the breech.

Of course, some of the guns burst due to the explosion of shells in the bore, but unfortunately not much was understood of the tremendous heating effect of burning powder, and many Ordnance officers, even with ample opportunity for field observation, believed that little heat was communicated to the guns. Since the designers were sure their guns could withstand the pressure

of the exploding powder, bursting was often attributed to the "mysterious force of gunpowder."

Rapid firing was more likely to cause bursting than slow firing, for the guns had thick walls, and the interior could become quite hot while the exterior remained cool.

The heavy rifles, when used for siege purposes, were quite formidable and proved themselves superior to smoothbores in all respects. At Fort Pulaski, even the 30-pound solid Parrott projectiles gave about a third more penetration into the brick walls than did the 128-pound solid shot from 10-inch columbiads. They were more accurate, too.

Not only were time fuzes available for placing in the nose of rifled shells, but percussion fuzes also had been developed. The Hotchkiss type consisted of a brass case containing a plunger. A priming charge was carried in the plunger and topped with a cap of fulminate.

On striking the target, the plunger was thrown forward firing the cap against a pointed anvil. This ignited the primer which, in turn, ignited the charge within the shell. Of course, safety devices also were incorporated to prevent an accidental discharge. Against Fort Pulaski the percussion shells also were very effective.

Besides the 10 rifles and 4 smoothbores used to open the breach, 22 other pieces, mostly 13-inch mortars, also were fired into the work at a range of from 1,650 to 3,400 yards. These mortars were strange-looking pieces, their length of fifty-five inches being only slightly greater than their 43-inch diameter.

The mortar weighed over 17,000 pounds and threw shells weighing 200 pounds.

THE largest gun in the war, and, indeed, in the world at that time, was the tremendous 117,000-pound, 20-inch Rodman cast by Charles Knap. Originally considered experimental, it was finally mounted in the defenses of New York harbor and succeeded in throwing a 1,080-pound projectile 8,001 yards with 200 pounds of powder. Of course it never had to defend either New York or its reputation in battle, and was fired only four times before the end of the war.

The South, having only one first-class foundry and only a few second-class foundries at the beginning of the war, was hard pressed for artillery of all kinds, and the situation never let up throughout the Confederacy's existence. However, the captured Federal forts and navy yards were reasonably well stocked, and many of these guns, for instance the older columbiads, were improved by banding, while some of the smaller smoothbores were rifled. There were also a few of Confederate invention, such as the Brooke rifle, although it was a banded gun and greatly resembled the Parrott.

BEFORE the blockade became effective, guns were imported from abroad—brass Napoleons from France, Whitworths and Armstrongs from England, and even a giant 600-pounder Blakely, also English, that served in the defenses of Charleston.

The large variety of guns increased the difficulty of supplying ammunition, and at no time was it unusual for a battery to consist of several types of pieces. The blockade and the capture of its foundries and ammunition factories finally doomed the artillery service, although by that time the Confederacy itself was doomed, and there were few to notice or care.

New Army Vehicles

The Army's new 8-ton amphibious vehicle, the Drake, above, can haul cargo items as large as an 8-ton truck. Engineering features include air-ride suspension, retractable wheels and axles, and propeller steering (Army photo). The new 54-ton M48A2 tank, below, is armed with a 90-mm. gun, 4 machine guns, and is designed to protect its 4-man crew from atomic blast.

Defense Highlights: Monthly Review and Outlook

• **The dispersal of our air power** offers a valuable object lesson for the country as a whole. The Air Force will place active bomber units of the Strategic Air Command at eleven bases as part of a move to safeguard the Nation's first-line striking force. When the units are built up, they will be operated by 1,500 to 2,000 men. The transfer of units will take place during the next 2½ years. The eleven bases are: Dow, Maine; Beale and Mather, Calif.; Clinton-Sherman, Okla.; Griffiss, N. Y.; Minot and Grand Forks, N. Dak.; Columbus, Miss.; and Bergstrom, Sheppard, and Amarillo, Tex.

• **A new official national speed record** of just over 1,015 miles an hour was established last August by the Navy's newest fighter aircraft, the Chance Vought F8U Crusader with Comdr. Robert W. Windsor at the controls. It was the first time the American figure for airplanes taking off under their own power topped 1,000 miles an hour. The Bell rocket plane, carried aloft by a "mother" aircraft, set the record for manned aircraft—more than 1,900 miles an hour. The Crusader is not the fastest United States plane. The Lockheed F-104 has unofficially flown similar speed courses about 400 miles an hour faster.

• **The new class of officers** entering the basic course at the Antiaircraft Artillery and Guided Missile School at Fort Bliss, Tex., were told that "we are not yet a completely missile artillery and it will be some years before we are." Maj. Gen. Robert J. Wood, school commandant, said: "You may wonder why so many of you are being trained in the technique of firing cannon rather than guided missiles. For an indefinite period in the future there will still be a great dependence upon conventional weapons which are highly effective within our planned capabilities. These are the weapons with which our troops are armed and they are ready and able to do the job against any enemy today." It is wise strategy to hold onto the old until the new is proved.

• **The Office of Defense Mobilization** has awarded 21 "phantom" contracts totaling $68.7 million to builders of general-purpose machine tools. No payments will be made on current contracts and no production started unless mobilization is declared. The purpose of the contracts is to ensure immediate tool production for the Government in an emergency. The agency plans to award some $250 million worth of contracts to 84 companies. It has set up $21 million to provide advances to producers of up to 30 per cent of the value of the contracts in the event of an emergency. The allocation of facilities for emergency production, while sound practice, has in the past been observed more in the breach than in the observance. We shall see!

• **An R.O.T.C. fellowship plan** intended to provide the armed forces with vitally needed scientific personnel has been established by Cornell Aëronautical Laboratory, Buffalo, N. Y. The laboratory will award an annual fellowship to the outstanding R.O.T.C. student at Cornell University, Ithaca, N. Y., who has qualified for a commission either in the Reserve of one of the armed forces or in the Regular Army or Air Force. With the permission of his branch of the armed forces, the fellowship recipient will pursue graduate studies at one of the university's engineering or scientific schools. The first fellowship winner will be selected from the 1956-1957 graduating class at Cornell. If the R.O.T.C. fellowship plan receives widespread support from American industry—as we hope it will—it will provide the armed forces with a steady influx of highly trained engineers and scientists so vital to our national defense.

• **The Muir S. Fairchild Trophy,** symbolic of outstanding unit skill in the fields of bombing and navigation, was won by the 11th Bombardment Wing of Carswell Air Force Base, Tex. Presentation of the trophy was made by Gen. Curtis E. LeMay, Commander, Strategic Air Command, in ceremonies following the conclusion of the Eighth Annual SAC Bombing-Navigation-Reconnaissance Competition. General LeMay had high praise for the maintenance men who kept all their aircraft in flying condition without a single abort occurring during the meet. He likened them to the linemen on a football team who seldom got the headlines. "It's like that with our maintenance men," he said. "If they weren't the finest, our combat crews might not get off the ground often enough to perfect their skills."

• **The Ordnance Guided Missile School** at Huntsville, Ala., graduated its 5,000th student in September. Capt. Herrold E. Brooks, Jr., received congratulations from Maj. Gen. John B. Medaris, commanding general of the Army Ballistic Missile Agency, and Col. Henry S. Newhall, school commandant. General Medaris told the graduates that "the only purpose of existence of the Ordnance Corps is to serve the line troops. We have the distinct privilege of sharing with other professions of outstanding importance, such as the ministry and medicine, the responsibility of not doing things for ourselves but of doing them for others. We must not forget that this is both a privilege and an obligation."

• **An 11,000-ton nuclear-powered surface craft,** "the forerunner of ships to come," is expected to be built next year by the Navy, according to Rear Adm. Albert G. Mumma, Chief of the Navy's Bureau of Ships. The Navy also expects to construct a nuclear-powered aircraft carrier. Although the emphasis is on submarines and capital ships, the Navy is

working on auxiliary craft also so that they can stay at sea for longer periods. Admiral Mumma stressed the fact that the transition from conventional to nuclear power in warships was going on gradually. Navy planning is guided by two major considerations—economy and the space and weight of nuclear power plants. It is not feasible to convert existing ships to nuclear power, but it might be possible in the future, if there were some great advance in nuclear development, to take a boiler out of a ship and put a nuclear reactor in its place.

• **In keeping with Admiral Mumma's announcement,** the Navy awarded Westingthouse Electric Company an $18.3 million contract for a nuclear reactor to power a light cruiser which will be constructed by Bethlehem Steel at an estimated cost of $87.5 million. The nuclear propulsion plant for the cruiser is being designed and developed by the Atomic Energy Commission in coöperation with the Navy. Although the Navy has no atomic-powered surface ships at present, it does have in use the one nuclear-powered submarine, the NAUTILUS, and another almost ready for fleet operations. Six others are planned in the 1957 shipbuilding program.

• **A new Air Force bomber** to be powered by high-energy chemical fuels was first mentioned publicly in General Nathan F. Twining's testimony before the Symington Airpower Subcommittee. The record just released by the Senate group gave no details. General Twining expressed the following views on changing concepts of warfare, the budget, and a single military service:

"I think our strategy has to change. For instance, we cannot afford to keep in our armed forces conventional forces for the old type of warfare plus those for atomic warfare. We have got to make up our minds which way we are going to go. And our mind is made up that we are going to develop a new strategy built around the use of atomic weapons of war, and once that is decided, we have got to give up some of these old customs. We have been slow doing that. That is one reason this defense bill is so high. We have got to make up our minds that we have to go one way or the other. That does not mean we don't retain in our force structure some conventional capability, not at all. We do. The nuclear weapon itself is here to stay and it is going to be used in war. We know that. So let's build our force around the new weapons. In this way we could reduce our forces considerably."

General Twining said the Air Force budget for 1958 would exceed $20 billion.

• **Hemisphere defense,** is again coming to the fore. The United States will implement President Eisenhower's plan for Western Hemisphere coöperation in developing nuclear electric power and other mutual-benefit programs. Our State Department announced that it had invited all American republics to name representatives to an Inter-American Committee that will draft concrete recommendations for coöperation in economic, social, and technical fields. There is a growing conviction at long last that now is the time to give real help to our neighbors to the north and south. Our east-west neighbors have thus far received the lion's share.

• **Guided-missile progress** and the atomic-age organization of the Army recently came under review at the Artillery Instructors' Conference which was held at the Artillery and Guided Missile School, Fort Sill, Okla. The annual session brought together representatives from the other branch schools, Marine Corps, and various Army agencies. The group had a look at the latest developments in ammunition, guns, guided missiles, and vehicles. They watched the emplacement of the 280-mm. atomic cannon and the erection of the Corporal guided missile. Special attention was given to the employment of surface-to-surface guided missiles and the latest developments in over-all fire support. Also discussed were concepts of new organizations of the Army believed necessary for atomic warfare.

• **The Army's new antitank missile, the Dart,** will be produced by the Utica-Bend Corporation of Utica, Mich., a subsidiary of Curtiss-Wright Corporation. The contract will amount to approximately $16,565,000. Developed by Army Ordnance under research and development contracts with Aero Physics Corporation of Santa Monica, Calif., also a subsidiary of Curtiss-Wright Corporation, the Dart is de-

Ordnance Day 1956 at Aberdeen Proving Ground was historic in many ways. It was the Thirty-eighth Annual Meeting of the American Ordnance Association, the A.O.A. being founded at Aberdeen in October 1919. As is shown in words and pictures elsewhere in this issue, more than 4,000 members were on hand to witness the program of tests and demonstrations of Army equipment. Army Ordnance, noted for the excellence of these programs through the years, never stood forth in finer perspective. The high degree of engineering skill, research, and design apparent on all sides was a tribute to the progressive outlook and sound principles on which the Ordnance Corps has operated for nearly a century and a half.

There were nine new armament items, developed by Army Ordnance and American industry, that had never before been shown to the public. They included: "Little John," newest of the Army rockets; the 105-mm. mortar; the 175-mm. gun; the 7.62-mm. general-purpose machine gun; the 30-mm. machine gun; the 20-mm. machine gun (the modern electrical version of the Gatling gun); the Dart, new in the family of guided missiles; and the 90-mm. tank gun. More will be reported on these weapons in early issues of this journal.

Never was there a more stimulating program and never a more distinguished company of military and industrial leaders to applaud the Army and its outstanding Ordnance Corps. Rain in the morning did not dampen the ardor of the audience or deter the weapons from displaying their superior firepower.

signed for employment against tanks by infantry and armored combat units.

• **The Navy's Distinguished Public Service Award** was presented to K. T. Keller, a director of the American Ordnance Association, by Acting Secretary of the Navy Thomas S. Gates at a ceremony in the Pentagon. The award was presented to Mr. Keller in recognition of his service to the Navy as Director of Guided Missiles, Office of the Secretary of Defense. Mr. Keller, was named to the then newly created post in 1950. Formerly chairman of the board of the Chrysler Corporation, Mr. Keller served as Director of Guided Missiles until 1953. The Navy citation said that "his foresight and decision added immeasurably to the Navy and Marine guided-missile program of today and of the future. Mr. Keller's expert appraisal and leadership abilities were of tremendous importance in achieving timely and vital results in the then new and important field of guided missiles."

• **Our Air Force in Europe** announced that it would activate a tactical guided missile wing—the Air Force's first—equipped with Matador missiles. Lieut. Gen. William H. Tunner, commander in chief of the United States Air Force in Europe, said the new wing would consist of three groups, the 585th, 586th, and 587th, each composed of three squadrons. It was put into operation in September. There had been one Air Force missile group in Europe until this new activation. It is stationed at Hahn Air Base, with its squadrons scattered over the near-by area. The Matador TM-61 missiles have a range of several hundred miles. They have never been launched in Europe, but practice firing is being carried out at a range in Libya, North Africa.

The Annual Industrial Preparedness Meeting of the Association will be held at the Waldorf-Astoria, New York City, on Wednesday, December 5, 1956. There will be a day-long program of technical seminars, directed by leaders of industry and the armed forces.

The morning seminars and their chairmen will be: Metallurgy, R. F. Mehl, Head, Metallurgical Department, Carnegie Institute of Technology, Pittsburgh, Pa.; Electronics, Daniel E. Noble, vice-president, Motorola, Inc., Chicago, Ill.

At midday there will be a luncheon at which Maj. Gen. J. B. Medaris, Director of the Army's Guided Missile Agency, will speak.

The afternoon seminars will be on Instrumentation, Col. Ralph L. Goetzenberger, vice-president, Minneapolis-Honeywell Regulator Company, Washington, D. C., chairman; and Propulsion, Charles W. Guy, assistant manager, Propulsion Center, North American Aviation, Inc., Los Angeles, Calif., chairman. Each panel will be manned by experts from the Army, Navy, and Air Force.

At the Annual Industrial Preparedness Dinner that evening in the ballroom of the Waldorf, the honor guest and principal speaker will be Adm. Arleigh A. Burke, Chief of Naval Operations. He will be awarded the Association's Blandy Gold Medal for distinguished service. Already there are indications that the ballroom will be filled to maximum capacity.

• **Chemical warfare** has been outlawed by treaty, but the Army Chemical Corps is ever on the alert to keep the Nation abreast of latest developments in the field. New detectors have been perfected at the Army Chemical Center, Edgewood, Md. The most recent examples are chemical alarms that give out warnings in the presence of minute quantities of deadly gases. These latest additions to the national defense include chemical crayons that make war gases draw their own portraits and instantly detect such deadly gases as phosgene, prussic acid, Lewisite, and cyanogen chloride. Each gas requires a specific detector. The report on the chemical crayons was presented at a symposium on air pollution by Arnold Prostak, physical chemist at the Chemical Warfare Laboratory at Edgewood, in collaboration with Dr. Benjamin Witten. They credited several other scientists in the development of the various crayons. Although originally developed for wartime use, the detector crayons are expected to have peacetime application in air pollution and smog-control studies.

• **A new technical laboratory** for housing missile data reduction facilities has been completed at the Air Force Missile Test Center, Patrick Air Force Base, Fla. The laboratory is the key to the testing area for intercontinental missiles. The building has 198 rooms and 123,500 square feet of floor space with walls of cement block panel construction to withstand winds of 120 miles an hour. It was designed to meet present and future needs of the data reduction component of the Missile Test Center. Former facilities hampered efficiency because of the problem of maintaining temperature and humidity conditions necessary for the precise functioning of delicate electronic equipment.

• **Lawrence W. Bell,** founder of Bell Aircraft Corporation in 1935, has resigned as president for reasons of health and has been elected chairman. Mr. Bell assisted Army Ordnance in the development of aircraft-mounted artillery. Under his direction, Bell Aircraft has grown to be one of the Nation's leading aviation concerns. In the past decade the company has grown from a military aircraft manufacturer into a diversified organization, engaged in the design and production of guided missiles, military and commercial helicopters, special research aircraft, electronics and servomechanisms, rocket engines, automatic control systems, and aircraft components.

• **The world's most modern aircraft carrier,** the FORRESTAL-class U.S.S. RANGER, was launched in September at the Newport News Shipbuilding and Drydock Company. She is 1,046 feet in length, the same length as her sister ship, the U.S.S. SARATOGA, and 7 feet longer than the FORRESTAL. In addition to having all the improvements of the SARATOGA, the RANGER has been designed with "major advances in her weapons-handling equipment." In addition to the FORRESTAL, SARATOGA, and RANGER, the Navy has been authorized by Congress to build three other sister ships.

Our Posture of Defense

An Editorial

THE status of our national defense, quite fortunately, was not a major issue in the 1956 election campaign. Possibly this was because the people are convinced that, basically, our national policy is sound and our posture of defense adequate.

It is not the function of this journal to comment upon political happenings, whether they be national or local. Nor are these comments intended to be a violation of that sound policy. The constitution of the American Ordnance Association provides that ours is a nonprofit, nonpolitical society of American citizens pledged to armament preparedness. That concept has the wisdom of time to support it, and it must ever be observed to the letter.

There is much cause for gratification that the American people are defense-minded—at least to the extent that they are convinced that there are no signs on the international horizon at the moment to warrant the lowering of our guard.

Adm. Arthur W. Radford, Chairman of the Joint Chiefs of Staff, sounded the note to which the vast majority of our people are attuned when he addressed the recent conference of Southern governors. Admiral Radford excoriated Communist leadership as a treacherous force "ready and set" to subdue and subvert any other ideology that obstructs its spread. The admiral's arraignment of Communism for duplicity was posed as a warning that the world situation "does not warrant apathy, complacency or self-satisfaction" on the part of the United States.

Admiral Radford then called for a "double-barreled program" in which military and civilian leaders would give to the youth of the country a Bill of Responsibilities to go with the Bill of Rights. With it, he said, they could demonstrate more effectively to the world what Americans mean by the principles of liberty.

In defining these principles, he noted, the governors share with the Nation's military leaders "the important task of protecting and preserving the fundamental beliefs and institutions of the United States." Similar words of good counsel have come from other defense leaders.

SECRETARY of the Army Wilber M. Brucker, addressing the Amvets National Convention in Milwaukee, asserted that this is certainly no time for Americans to let down their guard.

"As long as the Iron Curtain conceals the true situation within the Communist empire," he said, "there can be no safety in trusting the lives of our people to the doubtful meaning of words and smiles. If the curtain were lifted to admit the light of truth to peoples denied it for so many years, and if effective mutual inspection of armaments could be established, the free world could breathe a lot easier, and genuine peace would have a chance. In the meantime, we had better keep our powder dry and look to our defenses against aggression."

Mr. Brucker again underscored the menace of Communism at the Thirty-second Division Veteran Association Memorial Service in Detroit.

"Our Nation, our freedom, our lives, and everything we hold dear," he said, "are menaced today by the military might of the Communist conspiracy, the most dangerous the world has ever known. If we are to prevent that might from being used to commit armed aggression—and once again scourge the world with a terrible war—we must be strong, and we must stay strong as long as its shadow darkens the horizon of our future."

In a third address delivered at the commencement exercises of the United States Military Academy at West Point, Mr. Brucker pointed out that today we are challenged by an international conspiracy, backed by the largest mobilized armed forces on earth.

"Menacing as this armed might may be, it is only part of the over-all challenge we face. Of equal importance is the menace of a diabolical ideology of hate, atheism, and intellectual perversion which saps men's moral stamina, impoverishes their minds, and gnaws at their souls. The Communists know that if they could destroy America by either method, they could end all effective resistance to their plans to capture the world for Communism."

These eloquent and realistic remarks are being substantiated in a variety of ways.

Seven Western European nations agreed in September that there should be prior accord before any of them reduce their conventional armed forces in favor of nuclear weapons. The agreement was voted by West Germany, Britain, France, Belgium, the Netherlands, Luxembourg, and Italy.

THE United States, during the Middle East crisis, has about the same number of military units in the European-Mediterranean area as it had four or five years ago, but new weapons make them more powerful. For example, although the Sixth Fleet in the Mediterranean has not been increased it has greatly enhanced firepower through new weapons and increased aircraft performance and nuclear capabilities.

The Air Force announced it will step up the production rate of the Boeing KC-135 jet tanker airplane in order to increase the range and the effectiveness of our strategic bomber offensive.

The United States is rushing to completion a supply base seven miles out of Seville at San Pablo for its naval and airfield program in Spain.

Thus the American people, possibly for the first time in their existence as a nation, continue four years after a great war—the bloody, futile conflict in Korea—to give evidence of their firm conviction that a posture of continuing strong defense is essential to our survival as a nation. Let us pray God that it continue.

ASSOCIATION AFFAIRS

Artillery Division Holds Annual Meeting at the Naval Gun Factory

The Artillery Division of the American Ordnance Association held its 1956 meeting at the U. S. Naval Gun Factory, Washington, D. C., on September 20, 1956. J. E. Trainer, Firestone Tire & Rubber Company, the chairman of the Division, presided at this meeting.

Forty-five members and guests attended, including nineteen representatives of the armed services, and twenty-six representatives of American industry. In addition, several of the personnel of the Naval Gun Factory attended the technical sessions.

Dr. John L. Miller, Firestone Tire & Rubber Company, met with this Division for the first time as its new deputy chairman. He succeeded W. D. Gohr, who resigned last August as changes in his assignments removed him from direct connection with the activities of the American Ordnance Association. Dr. Miller was officially welcomed to his new duties of the Artillery Division at this meeting.

Joseph L. Auer, R. Hoe & Company, chairman of the Recoil, Recuperator, and Equilibrator Committee of the Division, was among those present and taking an active part in the discussions as also was Richard F. V. Stanton, West Hartford, Conn., chairman of the Gun Carriage and Mount Committee. William H. Mitchell, chairman of the Gun Forging Committee, unfortunately was unable to be present at this meeting.

The meeting was opened at 10 a.m. in the Naval Gun Factory auditorium by Rear Adm. David M. Tyree, superintendent, who extended the official welcome of the Navy Department. He paid a fine tribute to the late Brig. Gen. Thomas K. Vincent, whom he had come to know as a staff member of the A.O.A. and to respect most highly. Admiral Tyree also expressed the appreciation of the Navy Department for the splendid cooperation and technical advisory assistance afforded the armed services by American industry through the medium of the Technical Divisions and Committees of the American Ordnance Association.

Brig. Gen. Burton O. Lewis, from national headquarters, A.O.A., also paid tribute to General Vincent as one of the long-time stalwarts of the American Ordnance Association. With his wonderful personality he had endeared himself to all with whom he came in contact, and by his untiring efforts he had achieved an enviable record both in the Army and with the A.O.A. following his retirement from Army service.

J. E. Trainer, chairman of the Artillery Division, then took over the conduct of the meeting. He spoke briefly of the excellent work of General Vincent and the high regard in which he was universally held by all who knew him.

Mr. Trainer explained that the purpose of the annual meeting of his Division was twofold: first to present a technical review of the present status, developmental progress, and over-all problems pertaining to artillery matériel as seen by the representatives of the armed services —especially those of a general nature affecting the activities of more than one of the Committees of the Division—and, secondly, to afford an opportunity for all members of the Division to meet together to renew acquaintances, to discuss mutual problems relating to their Committee's activities, and finally to welcome the new members who had joined the Division since the previous annual meeting.

Mr. Trainer emphasized the solution of specific problems from the armed services as the best means by which the Technical Divisions and Committees of the A.O.A. could be of real advisory assistance to the services. In line with this thought, Mr. Trainer especially requested General Lewis to obtain from the Army, Navy, and Air Force their current problems relating to artillery matériel and to forward this list of problems to him for his transmittal to the various Committees of the Division.

Mr. Trainer then introduced the following officers who presented technical papers:

Col. Samuel Smellow, chief of the Artillery Branch, Research and Development Division, Army Ordnance, presented a paper entitled, "Major Items of Artillery." This was an historical review of World War II types of artillery together with important new standards developed to date—well-illustrated by still and moving pictures.

N. S. Glassman, chief of the Carriage Section, Artillery Branch, Ordnance Research and Development Division, presented a paper entitled, "Artillery Component Development." This proved to be a very interesting discussion concerning improvements in details pertaining to present standard types of artillery and among other things included some radical changes in our standard recuperator designs which greatly interested Joe Auer, chairman of the Recoil, Recuperator, and Equilibrator Committee of the Division.

"A Typical Missile Launching and Handling System" by Lieut. Comdr. C. A. Hill, chief, Surface Gun and Launcher Branch, Research and Development Division, Navy Bureau of Ordnance, proved most interesting to his audience inasmuch as it served to give them an insight into some of the problems of shipborne artillery of the future.

The final technical paper of the morning session entitled, "Applications Engineering Looks at Trends in Artillery," was delivered by Edward J. H. Lane, chief of the Ordnance Division, Directorate of Ordnance and Transportation, Office of the Assistant Secretary of Defense for Applications Engineering. This was an extremely interesting paper looking toward the artillery matériel of the future and the many involved problems incident thereto.

Before adjourning the morning session, Mr. Trainer, on behalf of the members of his Division and their guests, expressed the appreciation and warm thanks of all present to Admiral Tyree, superintendent of the Naval Gun Factory, and to his two staff officers, Capts. Charles E. Briner and Harry Hull, for the perfect arrangements made for this meeting.

The meeting adjourned about 12:30 p. m. for luncheon in the Crystal Room of the Officers' Club of the Naval Gun Factory. From 2:00 to 4:00 p.m. the members of the Division and their guests were given a specially conducted tour of twelve of the more important shop buildings at the Gun Factory.

• **AT ABERDEEN PROVING GROUND** the cadets of the annual Ordnance R.O.T.C. summer camp participated in a graduating ceremony on August 2nd at which the honor cadets were recognized by awards from the American Ordnance Association.

The late Brig. Gen. T. K. Vincent acted in behalf of the Ordnance Association at the presentation ceremony.

The following cadets were awarded A.O.A. decorations and a year's membership in the Association for their outstanding leadership and academic qualifications in each platoon:

In Company A—1st Platoon, Cadet C. R. Lewis, Jr., A. & M. College of Texas; 2nd Platoon, Cadet Charles H. Hamilton, Georgia Institute of Technology; 3rd Platoon, Cadet Mark S. Creviston, Jr., University of Illinois; 4th Platoon, Cadet Luther O. Cox, Jr., A. & M. College of Texas.

In Company B—1st Platoon, Cadet Russell R. McKinney, Jr., The Citadel; 2nd Platoon, Cadet Wilbert E. Asper, University of Illinois; 3rd Platoon, Cadet Lawrence R. Seggel, Lafayette College; 4th Platoon, Cadet Joseph C. Ray, Purdue University.

• **AT HOUSTON.**—The Texas Post held its annual meeting on September 18th at the Shamrock-Hilton Hotel, where almost 100 members turned out to greet the special guest of honor, Rear Adm. F. S. Withington, Chief of the Navy Bureau of Ordnance.

At the dinner meeting members and guests were greeted by W. H. Miner, Lufkin Foundry & Machine Company, Post president, who then introduced and installed the newly elected president, K. P. Campbell, Sheffield Steel Corporation.

Admiral Withington addressed the members on the subject of naval ordnance research. He gave them a broad picture of the areas in missiles and underwater warfare in which Navy ordnance is now concentrating its efforts.

The new officers and directors of the Texas Post are: K. P. Campbell, Sheffield Steel Corporation, Houston, president; Allan D. Blackledge, Cameron Iron Works, Inc., Houston, vice-president; Leo S. Bassett, Dickson Gun Plant, Houston, secretary-treasurer; and the following directors: Dr. J. T. Elrod, University of Houston; W. O. Hedrick, McEvoy Company; N. E. Hull, Hughes Tool Company; R. B. Kinzbach, Kinzbach Tool Company; W. M. Powell, Brown & Root, Inc.; and A. C. Sinclair, Long Reach Machine Works, all of Houston.

Brig. Gen. Thomas K. Vincent Dies; Was Consultant for A.O.A. Divisions

It is with deep sorrow that the American Ordnance Association reports the death of Brig. Gen. Thomas K. Vincent, A.O.A. staff consultant for Technical Divisions and Committees. He died suddenly at his home in Alexandria, Va., on Sunday, September 9, 1956.

General Vincent was appointed a second lieutenant of Field Artillery, Regular Army, as an honor graduate from Kansas State College, Manhattan, Kans., in 1916, entering active duty in October 1917.

As a young field artillery officer he served during World War I at Fort Leavenworth, Kans., and Fort Sill, Okla., followed by duty in the Philippines. He transferred to the Ordnance Corps in July 1920 and served at Frankford and Raritan Arsenals.

From 1925 to 1931 he was stationed at the Ordnance School at Watertown Arsenal and at the arsenal itself. Here he completed the advanced ordnance engineering curriculum at Massachusetts Institute of Technology and then for four years as officer in charge of the cold-working division he directed the activity that pioneered in America the development of the process for strengthening cannon by radial expansion under hydraulic pressure.

In 1931 he entered the Army Industrial College, Washington, D. C., and after graduation in June 1932 he was assigned to the Office, Chief of Ordnance, in the Artillery Division of the Manufacturing Service. In 1935 he was transferred to the Proof Division at Aberdeen Proving Ground, Md., where his four years of proof and test work were ideal indoctrination for his later assignment to Erie Proving Ground. However, before going to Erie he was returned to the Office of the Chief of Ordnance for a tour as chief of the Small Arms and Small Arms Ammunition Division and then went to the Hawaiian Department as assistant Ordnance Officer.

The general was recalled to the United States in December 1940 and given the task of building the Erie Proving Ground at Lacarne, Ohio. Here he was able to apply the experience acquired at Aberdeen to obtain smooth over-all operations of the proving ground where throughout World War II final acceptance tests were conducted for most of the artillery used by our forces overseas.

With Erie in full operation the general was transferred back to Washington in August 1942 for another long tour. He was successively executive assistant to the chief of the Field Service Division, assistant chief of the Production Service Division and chief of the Redistribution and Salvage Branch.

After a short tour at Springfield Armory the general was detailed in Europe where he served for almost two years as special assistant to the Chief of Ordnance, European Command, and later commanded the Ordnance Depot at Griesheim, Germany.

Brig. Gen. Thomas K. Vincent
1895-1956

December 1948 found the general back in proving-ground activities, this time as deputy commander of Aberdeen. In July 1951 he was promoted to brigadier general and given additional duty as commanding general, Ordnance Training Command.

In June 1952 General Vincent was appointed commanding general of Redstone Arsenal, Huntsville, Ala., the Army Ordnance Guided Missile and Rocket Center. Here he was in the thick of the development of the Nike antiaircraft missile and work on Corporal and Redstone. From this arsenal he was retired on August 31, 1954, after thirty-seven years of devoted commissioned service. Shortly thereafter he became a member of the A.O.A. staff.

General Vincent is mourned by the entire American Ordnance Association to which he had devoted so much energy for the past two years. He will also be greatly missed by the entire Army Ordnance Corps where he was widely known and greatly loved and respected.

Michigan Post Officials Visit Mines of the International Salt Company

A group of officers, directors, and members of the Michigan Post advisory board inspected the subterranean salt mines as guests of the International Salt Company on June 25th.

Ready to inspect salt mines are, standing left to right: Henry Tuttle, Capt. M. T. Martin, U.S.N., John Dykstra, J. K. Fulks, H. R. White, F. W. Parker, Jr., Brig. Gen. L. S. Bork, Louis Multane, C. L. Jacobson; kneeling left to right are J. F. Gordon, J. F. Forster, Charles W. Brownell, and Capt. A. G. Haggis, U.S.N.

The trip followed a luncheon meeting to honor the Post's Advisory Board—the elder statesmen in Michigan's A.O.A. affairs.

More than a thousand feet below the city of Detroit, the members viewed mining operations covering an area of about 300 acres. Electrified heavy-duty construction shovels, trucks, and scrapers mine the salt from the Salina formation, creating huge vaulted avenues 50 to 60 feet wide, 22 feet high, and 1¼ miles long. Comments like, "A second Fort Knox" and "Ideal refuge from an atom bomb," characterized the reactions to the vast caverns. The accompanying photograph shows the group before the inspection trip.

Underwater Ordnance Division Holds Classified Meeting at Norfolk, Va.

The Underwater Ordnance Division of the Association under the chairmanship of Adm. A. G. Noble, Vitro Corporation of America, held a classified meeting at the U. S. Naval Station, Norfolk, Va., on Thursday, September 27, and Friday, September 28, 1956. During these two days there were meetings of the Division as a whole and separate meetings of the individual Committees.

The meeting was well attended with nearly one hundred per cent attendance of the membership of the three Committees; namely, the Fire Control Committee under the chairmanship of L. W. Imm, Librascope, Inc.; the Mine Committee under the chairmanship of J. McW. Stone, DuKane Corporation; and the Torpedo Committee under the chairmanship of Dr. G. R. Tatum, Vitro Corporation.

The meeting on September 27th, was opened at 10 a.m. by Capt. B. N. Wev, commanding officer, U. S. Naval Station, Norfolk, Va., who welcomed the group to the station and extended to them every courtesy and the hospitality of his command.

The entire Division then had the pleasure of listening to an address by Rear Adm. F. S. Withington, Chief of the Navy Bureau of Ordnance, Washington, D. C. Admiral Withington discussed in considerable detail the program of the Bureau of Ordnance for armament developments needed by our Navy. He also outlined some of the major problems which it will be necessary to solve in order to ensure a more effective program.

The afternoon was devoted to meetings of the three Committees of the Division. These meetings permitted discussion of their specialized problems and also the preparation of the Committee reports to be made to the Division chairmen on the following day.

The meeting of this Division was resumed at 8:30 o'clock on Friday morning, September 28th. At this meeting Rear Adm. W. K. Mendenhall, Jr., commander, Operational Development Command of the Atlantic Fleet, discussed the importance of underwater ordnance development to the Navy. He also outlined in some detail the manner in which this program is being organized and carried out.

The members, guests, and service representatives of this Division were afforded an opportunity to visit two ships and inspect certain features in which they were particularly interested in connection with the activities of the Underwater Ordnance Division.

During the afternoon, Admiral Noble presided and received the reports of activities from the three Committees of his Division. Admiral Noble was pleased to note great progress achieved by all three Committees, and he warmly complimented the chairmen and Committee members for their excellent work in this vital area of national defense.

In closing the technical sessions of the Division, Admiral Noble expressed the deep appreciation of all members of the Division for the many courtesies and the wonderful hospitality extended to them by the officers and men of the U. S. Naval Station at Norfolk.

The Division made tentative plans to hold the next meeting at Pasadena, Calif., sometime during the spring of 1957, leaving the exact date and place to be announced later.

The Association is most fortunate in again having the services of Brig. Gen. Burton O. Lewis as its staff consultant for Technical Divisions and Committees. This is an assignment to which he gave superb leadership until his retirement a year and a half ago. Immediately after the sudden death of General Vincent, as recorded on page 447, General Lewis graciously offered his services. They were accepted immediately by the Association's vice-president for divisions and committees, Louis Polk, and by the general chairman of these groups, Col. Henry N. Marsh. Thus, the important work of the Technical Divisions and Committees will go forward without interruption and under the skilled guidance of an experienced and faithful coworker.

Post Activities

Dr. J. W. McRae Addresses Meeting of Albuquerque Post at Kirtland Air Force Base

The Albuquerque Post resumed its monthly meetings on September 6th, with an informal dinner at the Kirtland Air Force Base Officers' Club. Guest speaker of the evening was Dr. James W. McRae, president of Sandia Corporation of Albuquerque. Dr. McRae, vice-president of Western Electric which operates the Sandia Laboratory for the Atomic Energy Commission, was an enthusiastic speaker on his subject—"The Common Defense."

Dr. James W. McRae

After his introduction by Post President Rear Adm. W. W. Juvenal, Dr. McRae outlined our country's history of scientific and industrial preparedness from the Revolutionary War down through today's AEC, terminating his remarks with the observation, "We don't have to worry about our system of common defense as long as we can get together as we are tonight and argue about it."

An enthusiastic audience of A.O.A. members from Sandia, AEC, Lytle Engineering & Manufacturing Company, and the Air Force Special Weapons Project at Kirtland AFB, as well as other representatives from New Mexico industry and business warmly received his remarks. Dr. McRae has been with Western Electric Company since 1937.

While one of the last Posts to be chartered (November 1, 1955), the Albuquerque organization is forging ahead with tremendous strides—the membership now totaling over 200. The last meeting was attended by 148 members and guests of the Post.

(*Continued on p. 452*)

Photo courtesy of Caterpillar Tractor Co., Peoria, Ill.

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High ultimate strength of HTM castings helps the famous Cat D7 Tractor do the tough jobs day-in and day-out. Vital parts, such as the front idler adjusting nut shown, are made from HTM metal . . . the metal with the high ultimate strength that resists wear and fatigue under heavy loads.

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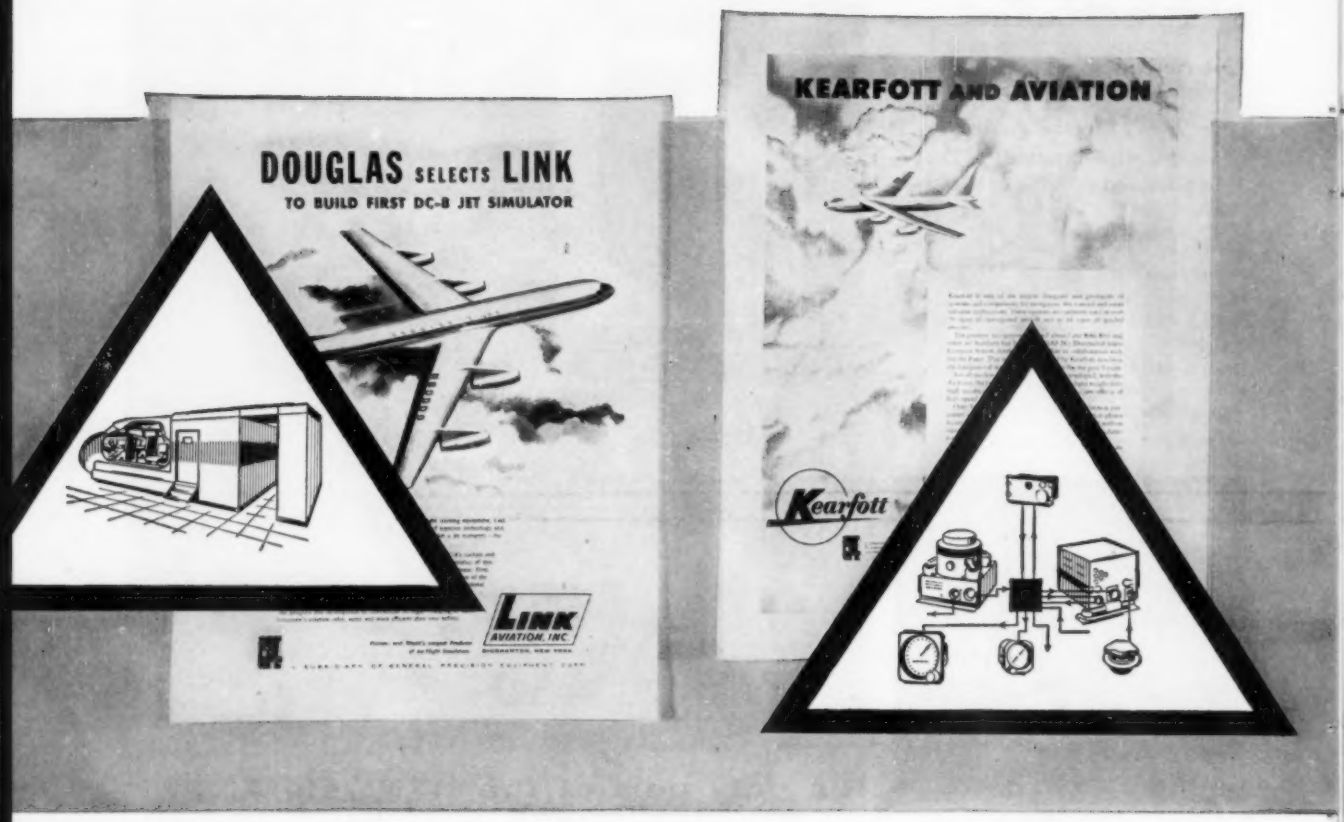

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have made vital contributions to the progress of jet aviation and its expansion into the civil transport field. Many have won recognition as the finest in the industry, bench marks of American technology.

Whole generations of airmen, for instance, have been trained in flight simulators developed and produced by Link, pioneer of on-the-ground flight training. This GPE Company has delivered over 800 jet flight simulators—more than all other manufacturers put together. It has just been selected, on the basis of superior technology and equipment, to produce America's first simulators for jet air liners. Link-developed DC Computer Systems in Link supersonic simulators are the only ones meeting the needs of these advanced aircraft.

Equally dominant are the gyro-magnetic compass systems of Kearfott, another GPE Company. This company's new lightweight J-4 Compass System weighs only

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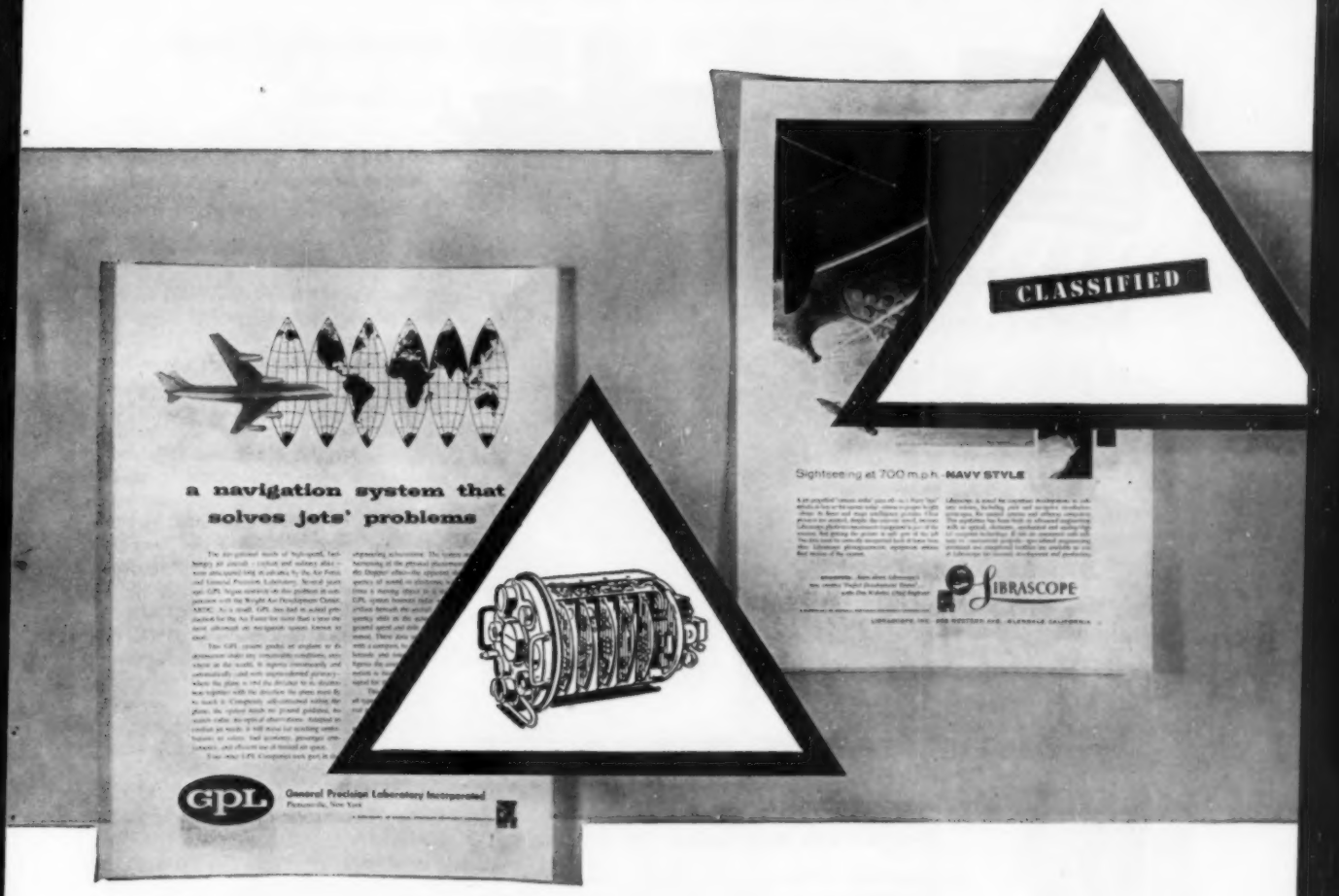

BENCH MARKS

18 pounds. Yet it provides accurate heading information at all latitudes, is rugged enough to maintain its high accuracy despite the jolts and speeds of jet flight. The Air Force has just selected it as standard for all new fighter craft. Kearfott's N-1 Compass System has been the navigational standard for Air Force bombers for 5 years.

Still another member of the GPE Group, General Precision Laboratory, has developed and is currently making quantity deliveries of the most advanced airborne navigation systems in use. These GPL systems, which are self-contained and fully automatic, have flown millions of operational miles with unprecedented accuracy. Their adaptations to civilian jet needs—GPL's RADAN Systems—are expected to make equally far reaching contributions to the commercial jet transport field—in the way of increased safety, fuel economy, passenger convenience and efficient use of limited air space.

These are but some of the accomplishments in aviation for which GPE Companies, working in conjunction with the Armed Services, are responsible. Librascope, an important member of the Group, produces outstanding instruments and equipment for the field. Librascope's computers, its highly advanced equipment for photo-reconnaissance work and photogrammetric equipment for the interpretation of photo data, its periscopes, pilot and navigator finders, are all leaders. Several GPE Companies are deeply involved in inertial guidance, guided missile projects and certain nuclear power applications.

In all GPE achievements in the numerous industries in which the companies work, GPE Coordinated Precision Technology plays an important part by inter-relating the wide range of skills and resources of the Group. This operating policy, and each company's unremitting insistence on highest quality, are major reasons for the frequency with which GPE systems and equipment continue to set standards in their fields.

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Association Affairs (Contd.)

Post Activities

Col. Henry N. Marsh Receives Medal of Merit, the Army's Highest Civilian Award

Col. Henry N. Marsh was the recipient of the Army's highest civilian award—the Medal of Merit—at ceremonies in the Office of the Secretary of the Army in the Pentagon on September 27, 1956. Colonel Marsh had completed a year and a half of service as deputy to the Assistant Secretary (Logistics), Col. Frank H. Higgins. Army Secretary Wilber M. Brucker made the presentation. His congratulations were supplemented by those of Secretary Higgins and Gen. Maxwell D. Taylor, Army Chief of Staff.

Deputy Secretary Marsh had been on leave from his company, the Hercules Powder Company, since March 29, 1955, in order that he might fill this official assignment. As of October 1, 1956, he returned to his duties with the company in Wilmington, Del.

Secretary Higgins cited the long and faithful service of his deputy through the years—as an Ordnance Reserve officer, as a powder and propellant specialist during World War II and Korea, as the country's leading expert on rocket powder, and as an important adviser to the military in the administration of the offshore procurement program.

Colonel Marsh now resumes his official status as general chairman of the Ordnance Association's Technical Divisions and Committees. All his A.O.A. friends welcome him back with heartiest congratulations upon the performance of another patriotic service.

• **JOHN M. HANCOCK**, investment banker of New York, former presidential adviser, and member of Council of the American Ordnance Association, died at White Plains, N. Y., on September 25, 1956.

During the First World War as a commander in the Navy he served as a member of the War Industries Board in close association with its first Chairman, Col. Frank A. Scott, and later when the board was under the chairmanship of Bernard Baruch. He was also a charter member of the Ordnance Association.

John Milton Hancock—who claimed no relation to the founding father of that name—was born at Emerado, N. Dak. He was graduated from the University of North Dakota in 1903. At the age of 31 he was on duty with the Navy in China when World War I broke out. Then in the Navy eleven years, he was recalled

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Waterbury Tool is accustomed to ordnance problems. Since 1903 it has worked on military applications ranging from battleship turret controls to guided missile launchers. We have specialized in the design of completely integrated hydraulic systems and can also supply almost any combination of standard or special hydraulic components.

If you have any ordnance problem where extremely accurate control or exceptionally fast acceleration, deceleration and reversal are required, contact Waterbury Tool. We may already have solved your problem hydraulically.

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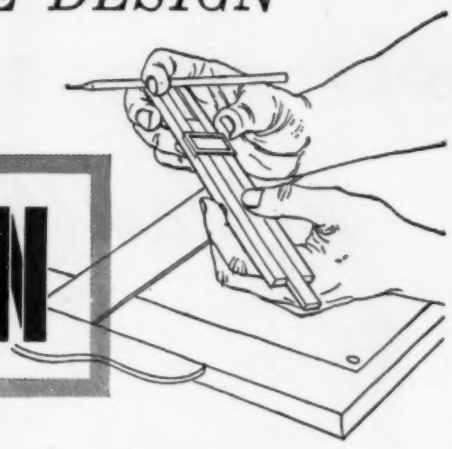

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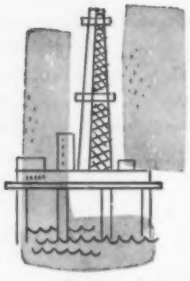

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Association Affairs (Contd.)

Necrology

to Washington and placed in charge of its purchasing division. As such he became the Navy's representative on the War Industries Board.

Following the war, Commander Hancock returned to civil life and was associated with the banking firm of Lehman Brothers where he remained throughout his long and useful lifetime.

Prior to and during the Second World War he assisted Mr. Baruch in many assignments of highest responsibility, some of which were the rubber survey and the international control of atomic energy. He was formerly also a member of the War Resources Board. In 1948 he was awarded the Army's Medal for Merit.

• **COL. EDWIN B. MEISSNER,** president of the St. Louis Car Company and former president of the St. Louis Post, American Ordnance Association, died in St. Louis, September 10, 1956. He was one of the founders of the Post in 1927 and succeeded the late Col. Harry Scullen as Post president.

Colonel Meissner began his industrial career in Milwaukee. In 1911 he helped reorganize the St. Louis Car Company, later becoming its president. It is one of the Nation's largest manufacturers of railroad cars and other transportation equipment.

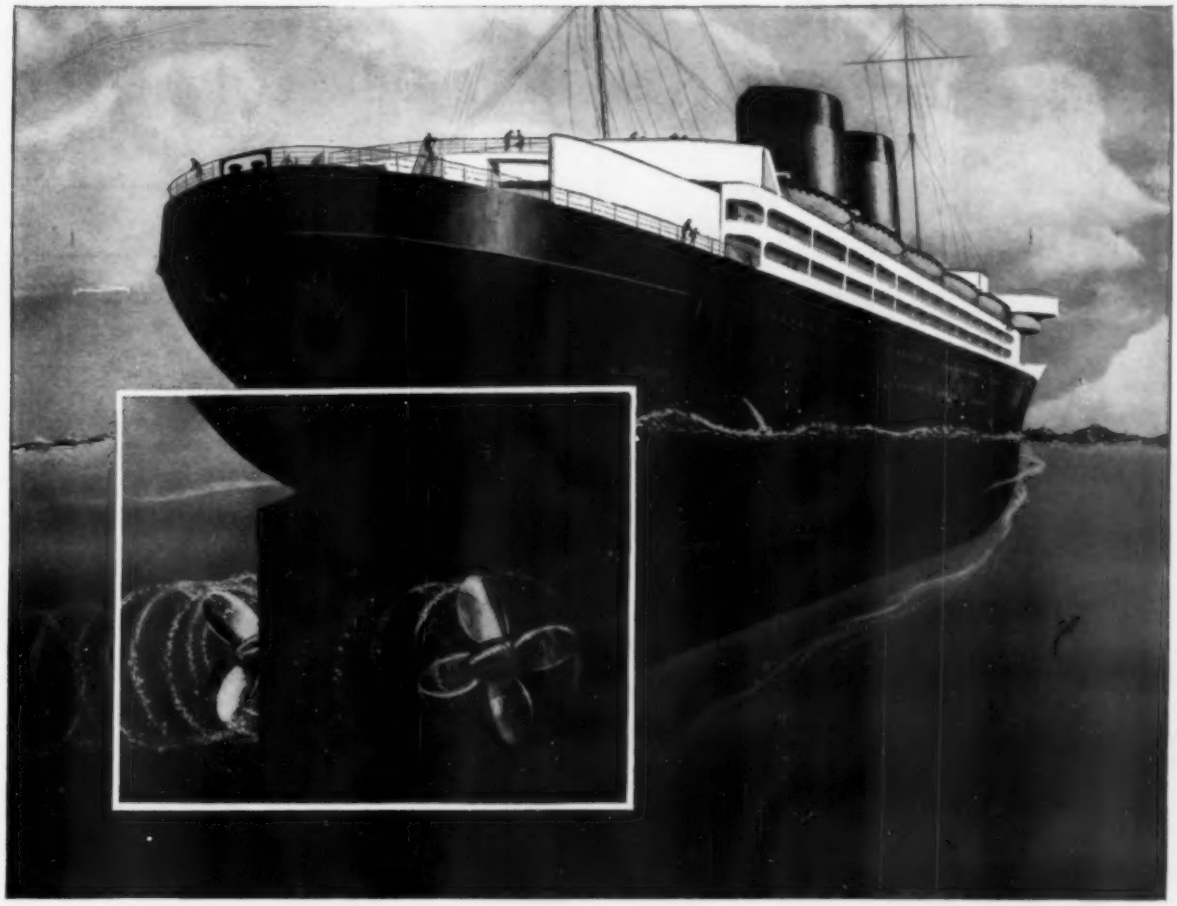
A former member of the Board of Police Commissioners of St. Louis, Colonel Meissner took personal responsibility for helping men and women paroled from prisons to obtain employment, offering many of them jobs in his own plant. In addition he was a native participant in charitable and civic projects in St. Louis.

• **ROBERT J. KELLEHER,** an industrial specialist for the Rochester Ordnance District, died at his home in Rochester on September 30, 1956. During World War II he served in the Office of the Chief of Army Ordnance and in the Office of Production Management in Washington.

He has been a member and a loyal supporter of the Association for many years and of tremendous assistance to the District Ordnance Office in Rochester since the war.

After being graduated from Pratt Institute in Electrical Engineering, Mr. Kelleher joined the old Northeast Electric Company in 1916 where he continued after it became the Delco Appliance Division of General Motors. During World War I he served as a captain in the Signal Corps.

For many years Mr. Kelleher managed the General Motors Delco Remy plant in Paris, returning to the United States after the fall of France in World War II.



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NEW DEVELOPMENTS

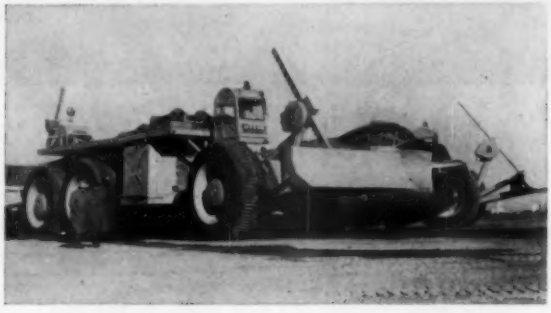
COMBAT HELMET RADIO

A combat helmet radio which enables soldiers to communicate with each other has been developed by the Army Signal Corps. Like the walkie-talkie, this new radio is battle-rugged and allows 2-way conversations. Weighing only a pound, the set was made smaller than two packs of cigarettes by use of transistors instead of bulky vacuum tubes.

To prevent enemy interception of messages at the front lines, the radio is preset for short-range conversations between squad members. But at a moment's notice range can be greatly increased by attaching an auxiliary antenna to the top of the helmet. At full capacity, the helmet can reach radios up to a mile away and can hear powerful stations at even greater distances.

GIANT BULLDOZER

The world's largest and most powerful bulldozer-type machine, designed for moving crashed bombers from runways, is so powerful that a pair of them can completely remove a 400,000-pound damaged aircraft in less than 20 minutes. The same task, using conventional equipment, formerly required from 5 to 15 hours.



Huge crash pusher has 'dozer blade at each end.

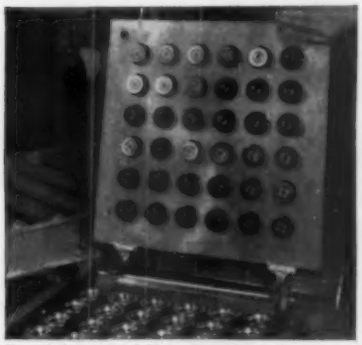
Primarily the huge vehicles, developed for the Air Force by R. G. LeTourneau, Inc., are designed for use during emergency operations when an aircraft has crashed and is keeping others from taking off or landing.

A powerful, high-torque electric motor is geared directly to each individual wheel making each one an independent drive unit. The machine is more than 67 feet long, more than 17 feet high, and more than 13 feet wide. It travels on 6 of the largest tires in the world—each being 10 feet high, 4 feet wide, and with a ground contact area of almost 1,500 square inches.

EARLY WARNING AIRCRAFT

The Navy has a new-type early warning research airplane—a WV-2 type Super Constellation, topped by a 30-foot, discus-shaped structure spreading over it like a parasol. This ellipsoid is a radome which houses the craft's distance-determining radar antenna. The aircraft will work with task forces as sentinels and combat information centers and as the seaward extension of the continental Dew Line of radar stations. (*Contd. on p. 458*)

Laboratory and service tests check compound resistance to oils, fuels and chemicals at high and low temperatures ...assuring the long life of Parker O-rings.



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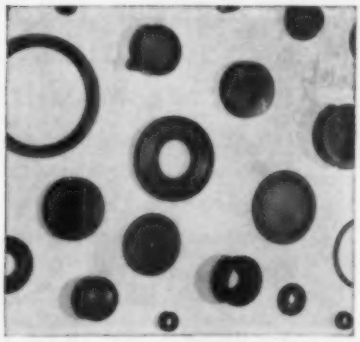

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Example of current Ordnance work—the Skysweeper. Production of this weapon has been continuous at the Ellwood City, Pa., plant since 1950.

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New Developments (Contd.)

LACROSSE MISSILE

A new surface-to-surface guided missile, Lacrosse, is now in production for Army Ordnance. Designed for close-support operation on the battlefield, with emphasis on accuracy and mobility, the essential components are the missile, a launcher mounted on a standard Army truck, and a guidance station. The Lacrosse system was developed under Army Ordnance contract by the Cornell Aëronautical Laboratory, Buffalo, N. Y., and is being produced by the Martin Company, Baltimore, Md.

HYPERSONIC RESEARCH ROCKET

The Air Research and Development Command recently announced the development of a research rocket that reaches several times the speed of sound in just two seconds. Called the Hypersonic Test Vehicle (HTV) it has been developed as a free-flight research tool to gather data at hypersonic speeds.

The first Air Force HTV, developed by Curtiss-Wright's Aërophysics Development Corporation, Santa Monica, Calif., in conjunction with ARDC's Wright Air Development Center, is now nearing standardization. Twenty experimental models already have been fired and tested at ARDC's Holloman Air Development Center, Alamogordo, N. Mex.

The HTV is a 2-stage solid-propellant rocket vehicle. The first stage is a 7-rocket booster which raises the 4-rocket second stage to a supersonic velocity. When the first stage burns out it falls away, and the second stage ignites and reaches the maximum velocity. It is with this stage that the hypersonic data are gathered.

The first stage is 5 feet long and 9 inches in diameter. The second stage is 5 feet long and 6 inches in diameter and is topped with a 2-foot nose cone. The nose cone is instrumented with a magnetic tape recorder. This device charts rocket acceleration and temperatures and pressures on the nose cone as the rocket travels at hypersonic speeds.

WINGLESS AIRCRAFT

The *Aerodyne*, a wingless fuselage lifted and propelled by an internal lift-inducing propulsion system, has successfully completed flights as a laboratory model. Air is sucked in through an opening in the top and expelled by high-speed fans past a set of control fins in the belly of the craft. The *Aerodyne* is able to hover for takeoff and landings.

ELECTRICITY FROM ATOMS

A method of converting atomic energy directly into alternating electric current is reported to have been developed. In this system the electrically charged particles, such as electrons and protons, emitted by the reactor are grouped into streams by electromagnets. The streams are reversed intermittently, and current is induced in secondary coils much as it is in an ordinary transformer.

WEAPON PLANS

A new technical military planning operation (Tempo) with responsibility for preliminary planning of future complex weapons systems which will prove decisive in preserving U. S. military strength and political freedom is being organized in the defense electronics division of the General Electric Company.

The principal object of Tempo is to bring together the fruits of advanced research, the apparent course of weapons development through the world, and the economic and demographic factors in international conflict in order to make recommendations concerning the selection and design of future complex weapons systems and thus to assure the U. S. of technological leadership in weapons systems and to provide maximum defense per dollar in these systems. (*Continued on p. 460*)

From Tokyo to Thule the Air Force meets the Solar Serviceman

GAS TURBINE ENGINES are gaining ever wider use in military service . . . for airborne generator sets, ground support units and many other applications. Solar Field Servicemen constantly visit Air Force bases and Armed Service evaluation centers establishing training programs and checking installations. Solar's Field Servicemen are a vital part of the team that has produced the trouble-free record of Solar gas turbines.

Solar builds both the Mars 50 hp and the Jupiter 500 hp gas turbine engines. The Mars is now in use on the Lockheed C-121C, Douglas C-124C, Convair C-131B and the Boeing KC-97 tanker. The Jupiter is being produced as a compressor pack and in variable and constant speed versions for other applications.

The proven dependability of Solar gas turbines is the result of nearly three decades of experience in engineering and fabricating precision products of alloy steels for severe service. Can this experience help you solve a complex engineering or manufacturing problem? For information write Dept. C-83, Solar Aircraft Company, San Diego 12, California.

WRITE FOR BOOKLET...new brochure describes Solar gas turbines – how they work, advantages they offer to forward-looking industries. Send for a copy today.

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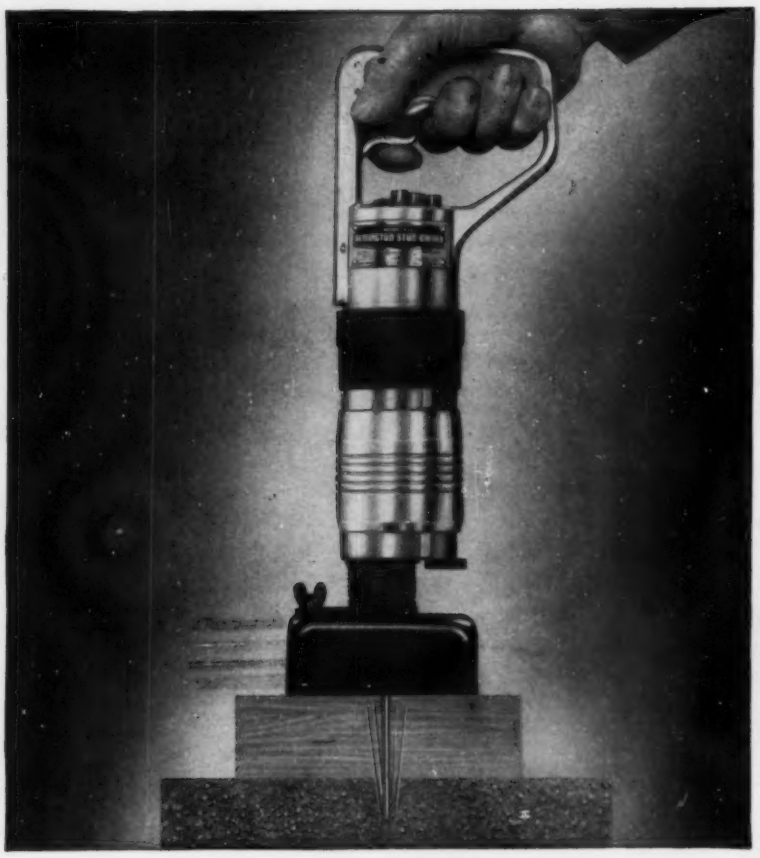
SAN DIEGO SOLAR DES MOINES

ENGINEERS WANTED *Unlimited opportunities in Solar's expanding gas turbine program! Write today, giving experience.*

Designers, Developers and Manufacturers • Gas Turbines • Aircraft and Missile Components • Bellows • Controls • Coatings • Metal Alloy Products



Just a squeeze sets the fastening stud in steel or concrete!

THAT'S HOW SIMPLE IT IS—a flex of the finger—to anchor fixtures securely with the Remington Stud Driver. Off goes the power load, the stud is anchored into steel or concrete—straight as an arrow. No predrilling or outside power source required!

You can set both ¼" and ⅜" diameter studs with the Remington Stud Driver—up to 6 studs per minute either size. There are 40 different styles and lengths of Remington Studs to choose from. With this *one* tool, you can take on *every* stud-fastening job—light, medium and heavy-duty—and save time and money on every one of them! Get full details by mailing coupon below.

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Industrial Sales Division O-11
Remington Arms Company, Inc.
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New Developments (Contd.)

NEW TANKER AIRCRAFT

The Convair R3Y-2 Tradewind is the world's first seaplane tanker capable of simultaneously refueling four fighter aircraft. Four Grumman F9F-8 Cougar jet fighters from VF 123 squadron, Miramar Naval Air Station, San Diego, Calif., recently were refueled in less than five minutes from the R3Y's four wing tanks.

The 4-engined turboprop Tradewind carries enough fuel to service eight fighter planes. It was designed as a dual-purpose tanker-transport and is one of eleven such aircraft built for the Navy by Convair, a division of General Dynamics Corporation. Several of the high-speed seaplanes already have been delivered to the Navy.

ELECTRONIC NAVIGATOR

A highly accurate, lightweight, completely self-contained airborne electronic navigator has been developed by General Electric's light military electronic equipment department under U. S. Air Force contracts totaling several million dollars. The 150-pound system will eliminate manual navigation problems for pilots of jet fighters who, when operating at today's speeds and ranges, have little margin for navigational error.

The system does not depend upon any form of ground information or control and can navigate a plane between any two points on the earth's surface. The system provides the pilot at all times with an indication of his present position, along with the course to fly and distance to destination.

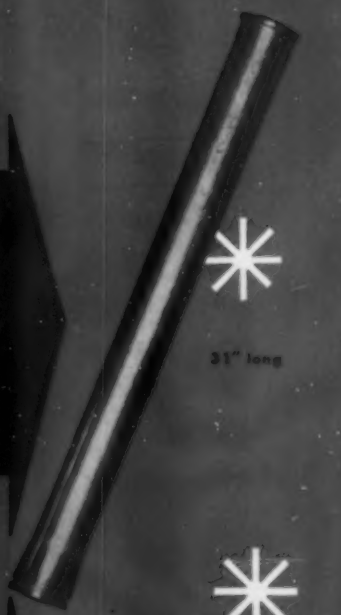
ARMY TEST CENTER

An Army Combat Developments Test and Experimentation Center has been established at Fort Ord, Calif. Troops of the 10th Regimental Combat Team of the 5th Infantry Division, stationed at Fort Ord, will be used in the combat testing with one or two battalions from the 10th RCT spending short periods of time in field work at near-by Camp Roberts and Hunter Liggett reservations. No change in the status of the three military installations is contemplated. The action will meet a long-standing Army requirement for centralizing the development and testing of new organizations, equipment, and tactics.

NEW MISSILE VESSELS

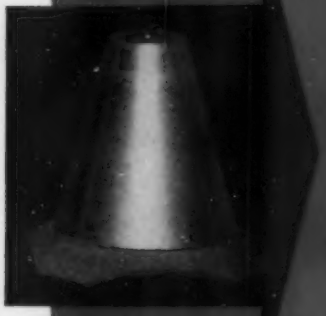
Conversion was begun recently on two merchant-type vessels in furtherance of the Navy's intermediate-range ballistic missile program. The first ship, the U.S.S. COMPASS ISLAND (EAG-153), formerly the GARDEN MARINER, is being converted at the New York Naval Shipyard. Conversion of the second ship (EAG-154), formerly the EMPIRE STATE MARINER, has

Why remove metal when you can move metal



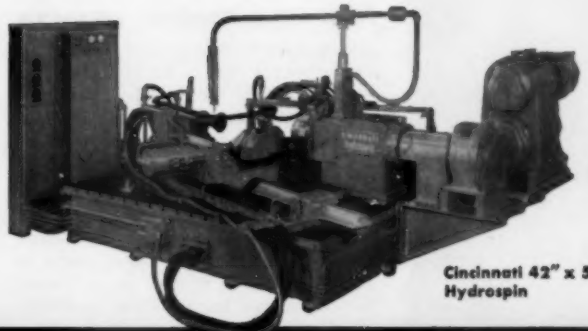
31" long

into the shapes you want with the Cincinnati Hydrospin



14" high

A wide range of parts can be produced quickly and at low cost by "*chipless machining*" on the Cincinnati Hydrospin. Less metal is wasted and parts have accurate dimensions, high strength and good finish. Let a Process Machinery Division field engineer give you full details. For a description of the process and machine specifications, write for Bulletin M-1873-3.



Cincinnati 42" x 50" Hydrospin

✳ Upper sequence of photos shows *one continuous* tube spinning operation. Starting blank, far left, of SAE 4130 is 8¾" long x 3" I.D. x 0.155" wall thickness. Finished part, shown at far right, Hydrospun in one pass, is 31" long x 3" I.D. with 0.030" wall thickness.

✳✳ Lower sequence of photos shows *one continuous* shear spinning operation. Starting blank, far left, is of type 302 stainless steel, 12" square x ¼" thick. Finished part, shown at far right, Hydrospun to a 32° included angle in one pass, is 14" high with 0.069" wall thickness.

CINCINNATI **Hydrospin**

PROCESS MACHINERY DIVISION
THE CINCINNATI MILLING MACHINE CO.
CINCINNATI 9, OHIO, U. S. A.

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Electromagnetic Cores and Shields

New Developments (Contd.)

been assigned to the Norfolk Naval Shipyard. These conversions are steps in the evolutionary process in the development of a fleet ballistic missile system, using the Jupiter missile.

NEW COIN DIMPLER

North American Aviation, Inc., has applied for a patent on a new, 2-piece ram for coin dimpling that could, it is claimed, save the aircraft industry hundreds of thousands of dollars a year. The new ram

New 2-piece ram, right, beside old ram.

is said to last three to five times as long as one-piece rams now in use and to be seven times cheaper to replace. Coin dimpling is a process used in making today's supersonic airplanes whereby a die forms a rounded recess under pressure on sheet metal so that flush rivets and countersunk screws lie flush with the surface and offer no wind resistance in flight. The new die has a hole drilled through the upper part so that chips and fragments drop through to the slotted button base instead of collecting around the sides as in the old dies. The new die can be made on an automatic tool machine.

MISSILE CAMERA

A new 16-mm. camera designed to record the characteristics of guided missiles while being carried aboard the missiles in flight has been developed by the Wollensak Optical Company, Rochester, N. Y. The camera is said to be so rigidly constructed that it will withstand severe vibrations and impact shock during launching, acceleration, and deceleration of the missile.

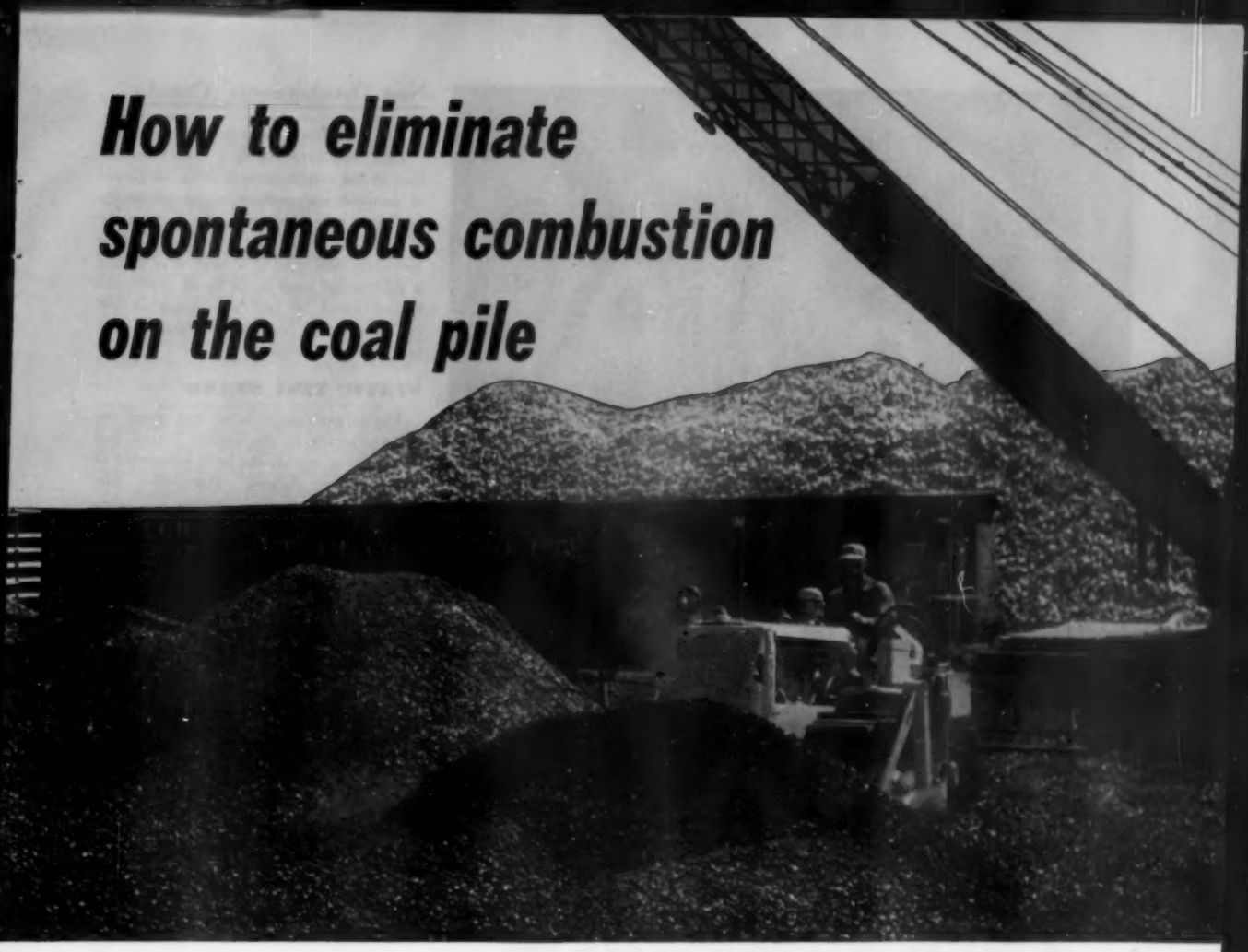
NEW ELECTRONIC DEVICES

New electronic devices and circuits that can withstand the terrific heat generated by air friction during the supersonic flight of aircraft and missiles have been developed by the General Electric Company. The devices can operate effectively at temperatures of 900 to 1,500 degrees Fahrenheit at which ordinary electronic tubes and circuits would melt. This means they can be packed into tight spaces to guide supersonic missiles or airplanes, without needing heavy cooling equipment.

ATOMIC FIREPOWER

A 280-mm. artillery shell with an atomic warhead will cause almost fifty per cent total destruction within the radius

How to eliminate spontaneous combustion on the coal pile



THERE are approximately a hundred thousand tons of coal in this stockpile. In the past, Amalgamated Sugar Co. of Nyssa, Oregon, continuously had trouble with spontaneous fires breaking out. They tried spreading and compacting the coal with a tractor of another make, but the machine was unstable when working on the edges of the pile and could not stand up to the severely dusty conditions.

Then the company called in a CAT* D2 Tractor to spread and compact the coal. Result: no more fires and complete compaction of the pile. The 7600-lb. D2 presses coal firmly into place to eliminate air pockets and has the stability and balance to work to the edges of the pile. Thanks to highly efficient filters and seals on engine and running gear, the Caterpillar D2 Tractor stays on the job even in heaviest dust. Note the respirator on the face of O. D. Storts, owner of the D2, who says, "I've always been a Cat man. As far as I'm concerned, there just isn't any other crawler tractor."

The new Caterpillar D2 Tractor is built to outlast and outwork any other machine in its class. Its rugged, four-cycle Caterpillar Diesel Engine requires only routine maintenance and delivers full power without fouling on money-saving No. 2 furnace oil. From its specially hardened track shoes to its easy, positive controls and unexcelled operator visibility, the D2 is traditionally Caterpillar in careful workmanship, quality materials and sound design.

The D2 is available with optional oil clutch for long facing life and prolonged freedom from adjustments. With a wide choice of attachments, the D2 can be "tailor made" to do most work at least cost on a wide variety of operations.

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

CATERPILLAR*

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MODERN TRACK-TYPE TRACTORS

A small pebble in a big pond....

Drop a small pebble in a big pond and the ripples created by the impact will travel in ever widening circles over the entire surface.

Ordnance is a vast pond and Vulcan is proud that its first impact as a small pebble soon reached the farthest bank.

This is borne out by Vulcan's steady growth and development since entering the field of Ordnance as Contract Machine Specialists and builders of fine Custom Precision Gages.

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Vulcan is big enough to serve you — yet small enough to give each contract, prompt personal attention.

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New Developments (Contd.)

of one mile from the point of detonation.

This was revealed in a recent discussion of the comparative destructive power of conventional and atomic-armed shells by Rep. Craig Hosmer on the floor of the House. In contrast, a typical 8-inch howitzer shell used in World War II had a destruction area of 20 to 80 yards and caused about 50 per cent casualties but not necessarily fatalities to those unprotected from its blast.

STATIC TEST STAND

The largest static firing test stand for rocket motors in the United States, and possibly the world, has been completed at the Redstone Arsenal, Huntsville, Ala. The huge test facility, started 2½ years ago and costing a total of $12,000,000 will be capable of testing the intermediate-range ballistic missile now being developed at Redstone Arsenal by the Army Ballistic Missile Agency under command of Maj. Gen. John B. Medaris. It may also test even more powerful missiles.

Static testing of a missile consists in locking the missile into place on the stand and firing it. The missile does not "take off," but as it strains against the mighty grip of the tower its roaring engine can be studied for performance characteristics as if it were actually in flight.

Redstone's test stand, built of reënforced concrete, towers 145 feet high—as tall as a 15-story building. Its walls are forty-eight inches thick. A "basement" for the stand extends twenty feet below the ground and is connected by underground tunnel to an observation and control blockhouse a thousand feet away.

The test stand itself is only a part of the entire test facility, being surrounded by a complicated layout of other buildings and devices including a boiler plant, a booster water pump station, an engine building, a nitrogen booster station, a guardhouse, a horizontal test stand, a components test laboratory, a cold calibration test stand, a propellant storage area, and a ready storage area.

FAST ROCKET SLED

Designed to carry an exposed part of an aircraft or missile through a simulated rainstorm at supersonic speeds, a rocket sled of the Air Research and Development Command has reached a speed of 1,560 miles an hour. The sled, equipped with 12 rocket bottles, reaches an acceleration of 25 times the force of gravity, and completes its run on a 10,000-foot track in a little more than 9 seconds. It is stopped in the last 2,000 feet of travel by a water brake. Telemetering equipment is built into the sled and a miniature radio transmitter beams information to a recording center while the sled is in motion. Special cameras which photograph the sled during high-speed runs are

capable of exposing film at a rate of 7,000 frames a minute.

NEW RADAR TUBE

A radically new type of cathode-ray tube for radar, television, and other visual electronic equipment has been developed by Sylvania Electric Products, Inc., under an Office of Naval Research contract. Officially designated as Tube Type 6762, it is known as the "Wamoscope" and derives its name from the technical term, "wave-modulated oscilloscope." It combines the most essential functions of a microwave receiving set in a single tube envelope, eliminating many of the tubes and components required by conventional receivers.

In the Wamoscope, microwave signals go directly from the antenna into the tube where the signals are amplified, detected, and displayed on the tube's fluorescent screen. Compared with a conventional radar receiver, this means that the local oscillator, mixer, intermediate-frequency amplifier, detector, video amplifier, and their associated circuitry are eliminated.

An important feature is the wide selection of channels possible since the tube operates over a microwave frequency band of 2,000 to 4,000 megacycles.

SURVEY RADAR

Radar has been put to a new use by the Army—measuring great distances for the surveyor. The "radar ruler," developed by the Army's Signal Corps Engineering Laboratories at Fort Monmouth, N. J., gives the surveyor 20-league boots. It frees him for the first time from short-sighted optical equipment, useless during poor visibility.

With the radar yardstick, the surveyor can measure off fifty miles in a single giant leap instead of twenty or thirty small hops, each requiring meticulous sighting. Even at greatest range the radar readings are precise to within a few feet.

Designed under Army Signal Corps contract by Motorola, Inc., Chicago, Ill., the new system uses two separate jeep-portable radar stations, one at each end of the distance to be measured. The entire radar station, a 25-foot collapsible antenna mast and 3 metal suitcases filled with electronic equipment, weighs only 200 pounds. It fits easily into the back of a jeep and can be set up and operated by one soldier.

FALLOUT COMPUTER

A special-purpose computer that gives the geographical fallout pattern of radioactivity resulting from a nuclear explosion has been developed by the National Bureau of Standards. Given the necessary weather data together with certain infor-

(*Continued on p. 468*)

with TI transistorized intercom

TI PRODUCTION ENGINEERING helped Lockheed trim 55 lb of dead load from the P2V-7 sub-hunting Neptune . . . by transistorizing just one system — the 14-station intercom. In addition to saving weight, safety and reliability were *increased* while maintenance and power drain were *reduced*.

Well within MIL-E-5400 for general performance, MIL-T-5422C for environment and MIL-I-6181B for interference, this TI-built system has been designed for a 2000-hr maintenance cycle and an exceptionally long service life. Signal response is instantaneous without need for warmup. There is negligible power drain on standby and negligible heat dissipation while in use. The system takes power directly from a 28 Vdc line and uses less than 6 watts per station.

This is one example of Texas Instruments *systems engineering* now being applied to audio, radio, radar, sonar, infrared, and other systems for communications, navigation, search, fire control, and missile control. Continuing progress over a quarter century has resulted in over a third of a million sq ft of engineering and manufacturing facilities — soon to be doubled — located in an excellent dispersal area.

For fundamental design and development . . . for manufacture of reliable systems that save weight, space, and power . . . for scheduled commitments delivered on schedule . . . call on TI application engineers. Write to Apparatus Division . . .

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Caravan automotive type trailer undercarriages assure the rugged, trouble-free mobility needed for the service life of your equipment. Soundly engineered for extra factors of safety, ease of fabrication in your plant, Caravan meets **Mil Specs** for all types of 2 and 4 wheel air and ground support equipment. Let United's engineers help tailor your trailer axle design to your load need.

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Compressors • House Trailers • Motor
Generators • Asphalt Mixers, etc.

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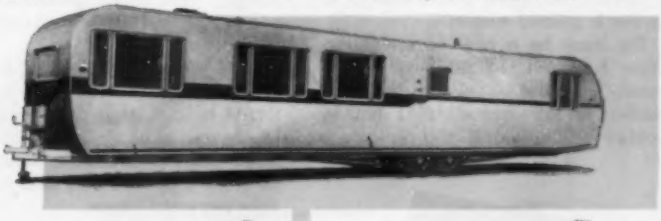
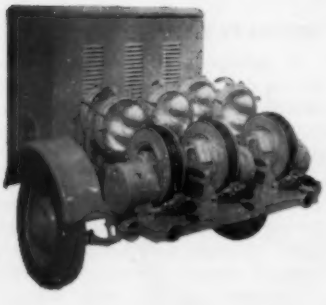
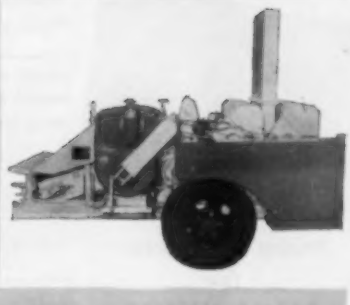






Picture of a young man Planning a Successful Future!

Success doesn't just happen to a company or to an individual. Success comes as a result of clear thinking and long-range planning.

And that is just what the young engineer in the picture is doing. He is studying the many possibilities of a career in guided missiles.

The book he is reading is entitled "Your Future in Guided Missiles with Bendix". It is one of the most complete guides to job opportunities in the guided missile field. It also contains a detailed background of the functions of the various engineering groups such as systems analysis, guidance, telemetering, steering intelligence, component evaluation, missile testing, environmental testing, test equipment design, reliability, propulsion and other important engineering operations.

Here is exactly the type of information that every ambitious engineer should have if he is concerned about his future. A copy of this thirty-six-page book is available to you. Just fill in the coupon. It may help you plan your successful future.

Prime Contractor for TALOS MISSILE

BENDIX PRODUCTS DIVISION
MISSILE SECTION
405C, Bendix Drive, South Bend, Indiana

Please send me a copy of the book "Your Future in Guided Missiles."

Name_____

Address_____

City_____

State_____

New Developments (Contd.)

mation about the bomb, this analog computer will assist in predicting what the distribution and intensity of radioactivity will be on the ground after the bomb has been detonated.

Problem solution is displayed on a cathode-ray tube, over which a map on a transparent backing can be laid. Radioactive intensity at any ground point up to 500 miles from the explosion can then be measured by the brightness at the corresponding point on the tube screen. The computer was developed for the Weather Bureau and the Atomic Energy Commission by H. K. Skramstad and J. H. Wright of the Bureau's analog computer laboratory.

AUTOMATIC VELOCIMETER

An automatic velocimeter has been developed and tested that almost instantaneously gives the velocity of sound in sea water. This highly reliable instrument has been designed and constructed at the National Bureau of Standards and more recently tested at the Navy Underwater Sound Labatory, New London, Conn. The work of developing this instrument was sponsored by the Office of Naval Research. The NBS-ONR velocimeter will provide answers promptly on the speed of sound to depths as great as 300 feet. Readings come in values that are immediately useful—the speed as a function of depth or the speed as a function of time.

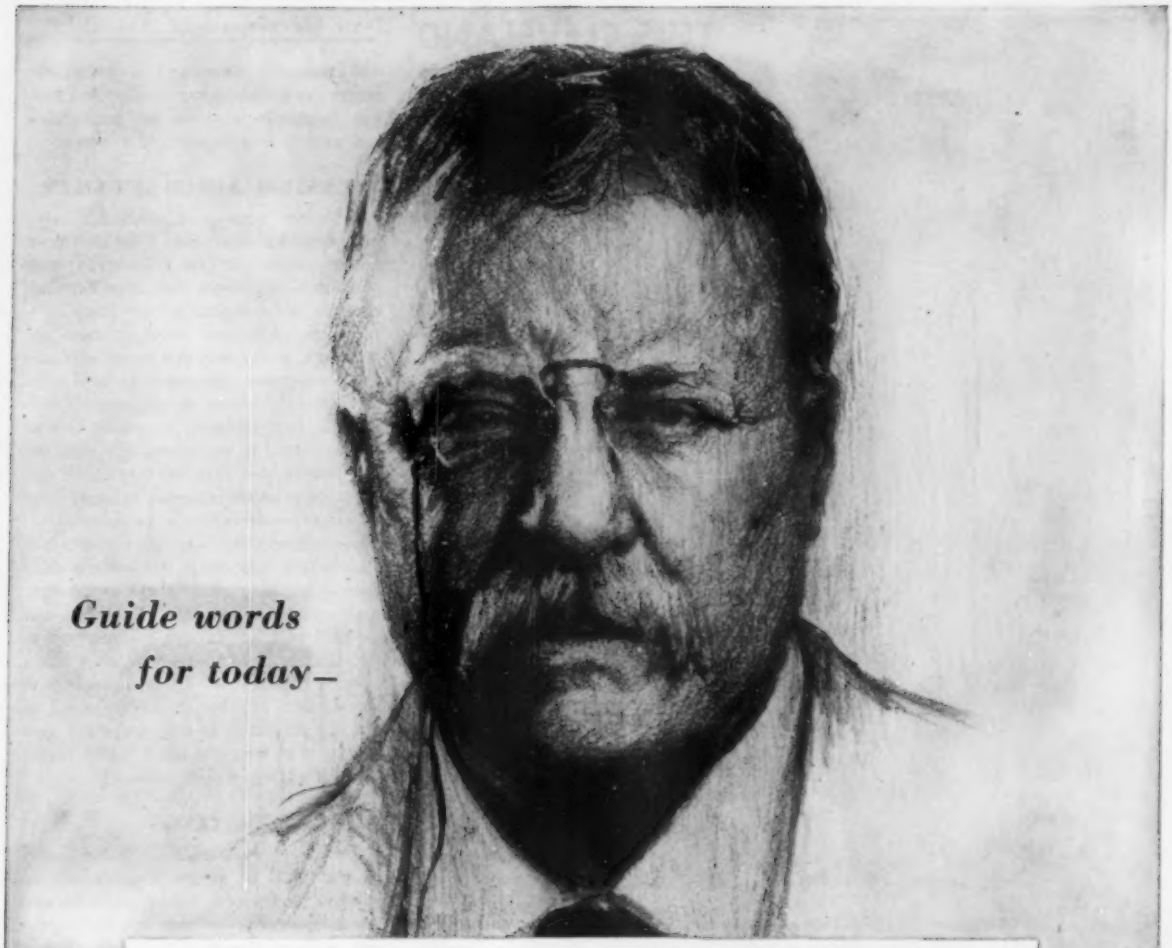
NEW SUPPLY SYSTEM

A new logistical concept called the Modern Army Supply System is undergoing field tests by the U. S. Seventh Army in West Germany. The system provides that supplies will be flown or shipped direct from bombproof storage points in the United States to forces in the field, doing away with the necessity for most rear-area supply bases overseas. Stock-control points in the United States will be equipped with "electronic brains" and supplies will be ordered by radio utilizing a simplified code. It has been estimated that deliveries will be speeded up as much as 600 per cent over the old system.

MINIATURE COMPUTER

A high-speed, airborne computer—until now destined only for the big bombers because of size and weight—may be miniaturized for use in fast Navy jet fighter aircraft.

The new type of digital computer, or so-called electronic "brain," may be used to consolidate the functions of many conventional airborne computers into a single compact system. Developed by Philco Corporation for the Navy Bureau of Aëronautics, the new Transac (transistor-



Guide words for today—

"The professed internationalist usually sneers at nationalism, at patriotism, and at what we call 'Americanism'. He bids us forswear our love of country in the name of love of the world at large. We nationalists answer that he has begun at the wrong end; we say that, as the world now is, it is only the man who ardently loves his country first who in actual practice can help any other country at all."

THEODORE ROOSEVELT

These prophetic words of the 26th President of the United States become even more significant today as the world looks to the United States for leadership against Communist domination. The salvation of the free world depends upon a strong America. And only a free people — believing heart and soul in duty and honor to our own country — can keep America strong.

PRESIDENT

Reprints of this series are available upon request.

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LABOR BUSINESS GOVERNMENT

The **GRAY** Manufacturing Company, Hartford 1, Conn.

Audograph, PhonAudograph and Telephone Dictation Systems

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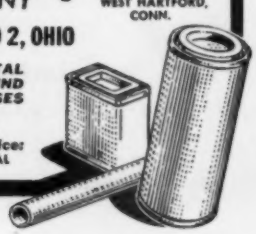

New Developments (Contd.)

ized automatic computer) control computers can process a typical aircraft problem involving hundreds of instructions and solve it in a thirtieth of a second.

TITANIUM AIRCRAFT SKIN

With new high-speed jets and missiles generating too much heat from both their power plants and air friction to keep aluminum skin from buckling, titanium sheet is being studied by the Navy as a substitute. Although titanium costs are still high, so far only this metal will take the temperatures generated by new military aircraft now in development. Titanium has been replacing aluminum as well as some steel in engine manufacture, but this marks the first time research has been begun to use titanium in sheet form as extensive aircraft exterior covering.

According to the Navy Bureau of Aëronautics the new sheet titanium in alloy form combining aluminum, molybdenum, and vanadium will keep its shape and remain uniform at temperatures up to 800 degrees Fahrenheit. This alloy has a specific gravity of 4.6 compared with aluminum's 2.8, but it can be used in thinner sheets. It is only forty per cent as heavy as steel and has a highly favorable strength-to-weight ratio.

MISSILE TESTING

Detecting weaknesses in fusion welds in the shells of guided missiles may be done in the future by sound waves beamed at a frequency too high for the human ear to hear, according to a new method developed by Army Ballistic Missile Agency scientists at Redstone Arsenal, Ala.

This method of inspection will permit scientists to probe the strength of the weapons while construction crews still are at work. Formerly, inspection was done by radiography, a method that required radiationproof walls and time to develop and evaluate the film on which the weak spots were recorded.

TOSS BOMBING

Jet fighters and fighter bombers can now come in at tree-top level with an atomic bomb, toss it in a high loop, and then maneuver away to escape the blast effects. The Minneapolis-Honeywell Regulator Company has developed instruments for a new bombing system that makes such delivery possible.

REGULUS II

The Navy has been testing a new model of the Chance Vought Regulus missile at the testing grounds at Chincoteague, Va. Dubbed the Regulus II, the new missile has greatly increased range over Regulus I. The new weapon can be launched from aircraft carriers, cruisers, or submarines, as well as from bases ashore.

THE SKY IS OUR WORLD

From advanced research into the fundamentals of the universe—gravity, nucleonics, astrophysics—to the development of many of today's most important flight and weapon systems, Martin engineering activities are among the most exciting in the aircraft industry.

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From design to production, Whittaker gyros are built with meticulous care. This includes continuous testing of components and assemblies and 100% inspection tests of all production gyros. With hundreds of gyros shipped each month, Whittaker has an overall customer rejection of less than 2%.

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MATERIALS PROGRESS

George S. Brady

The Growth of Plastics.—There have been great changes in the industrial materials supply situation since World War II, but probably no change has been more phenomenal than that caused by the rise in the use of plastics. Production of synthetic plastic resins this year is expected to be more than 2,000,000 tons, or more than twenty times the prewar production. From a very limited number of commercial plastics in 1940 the field has expanded to a point where there is an ever-growing variety of these materials with mechanical and electrical properties suitable for uses undreamed of before the war.

It is a mistake to look upon plastics as substitutes for metals. They form a new group of materials with new characteristics. Sales arguments now used for plastics are low cost, nonstrategic plentiful supply, corrosion resistance, light weight, more attractive product designs, and a wide range of inherent permanent color finishes requiring no painting. That they have displaced metals directly in some cases is merely coincidental; the outstanding point is that if there had not been this phenomenal growth of plastics there would now be a dire shortage of copper, zinc, and some other metals.

No study ever seems to have been made as to what impact these relatively new materials are having on the metals supply situation. Plastic products are sometimes produced from pure resins, but most plastics contain also plasticizers, fillers, and pigments, and the "plastic" products may well be twice the weight of the resins.

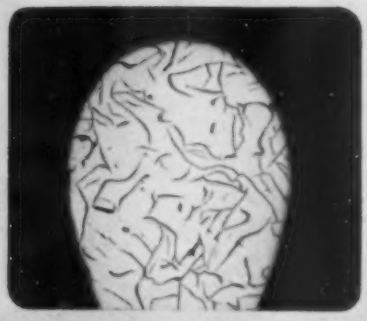
Probably fifty per cent of the resins produced are going into plastics that are directly competitive in use with metals, and, considering the additions of fillers to the resins and the difference in specific gravity between plastics and the metals, it is not unreasonable to assume that plastics are now displacing around 10,000,000 tons of metals. This is small compared with the use of steel, but it is very large compared with the supply of copper and zinc which the plastics are more directly replacing.

Because of strong arguments of the manufacturers during the Korean war, scarce brass and aluminum had to be allocated for the making of many civilian products for which plastics are now almost universally substituted. Representative of such items are flashlight cases and vacuum bottle cases. Items like lipstick holders and compacts were made by the millions in brass, but manufacturers found that with molded plastic parts a wider range of attractive styles could be offered at low cost. Close to twenty-five per cent of all toys are now made in plastics, and plastics are being used for innumerable housewares.

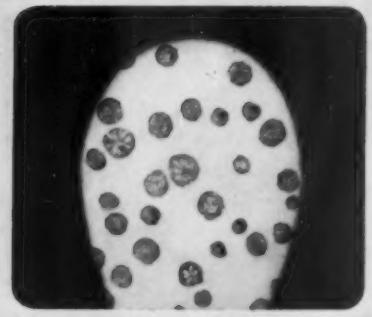
The ability of plastics to be molded into one-piece intricate shapes which require no finishing and eliminate previous difficult insulation problems has made possible light weight, compactness, and low cost in many electrical and electronic devices not otherwise obtainable.

Plastic Piping.—In the fast-expanding chemical industry, plastic piping has obviated a possible shortage of scarce strategic corrosion-resistant alloys. Probably eighty per cent of all this piping is polyethylene, a new plastic since the war. Within its strength range up to 2,500 pounds per square inch and its temperature capacity of 160 degrees Fahrenheit (the heat endurance is now being raised by radiation treatment), it is often preferable to corrosion-resistant metals because of the ease of installation, lower fluid resistance, and the visibility of flow.

NEW CAST IRON THAT BENDS



Ordinary cast iron, magnified 200 times reveals ribbons of graphite flakes distributed through the iron like a network of invisible cracks or voids. To the research scientist, this pattern explains why ordinary cast iron breaks if it receives an extremely sharp jolt.



New Allis-Chalmers iron has a completely different structure. Here, tiny balls of graphite are entirely surrounded by iron, giving it new strength and shock-absorbing ability, yet it is just as easy to cast and machine as ordinary cast iron.

—a contribution of Allis-Chalmers basic research

These photomicrographs are typical of the tools used by Allis-Chalmers scientists to develop a new kind of cast iron — as strong and flexible as steel, yet as easy to cast and machine as ordinary cast iron. Equally important, this new metal can be produced economically.

"Cast iron that bends" is already serving many users of Allis-Chalmers equipment—and will continue to serve them in ever-increasing numbers.

Exploring new frontiers has been a major factor in Allis-Chalmers' growth. Its accomplishments have been applied to such diverse fields as tractor equipment, electrical insulation, ore processing machines, plus many other civilian and military projects. Allis-Chalmers, General Offices, Milwaukee 1, Wis.

ALLIS-CHALMERS

Materials Progress (Contd.)

Its specific gravity is only 0.92, compared with about 8.0 for chromium-nickel alloys.

Cellulose acetate butyrate piping is finding use in the petroleum fields for crude-oil pipes and salt-water disposal lines. This plastic is somewhat heavier and stronger, with a tensile strength up to 6,700 pounds per square inch and a specific gravity of 1.2.

The plastics industry still retains the dynamic vigor of a new enterprise with new groups of plastics and new use applications appearing regularly. The *Danielson Manufacturing Company*, Danielson, Conn., is putting out a new line of nylon pipe, called Tempertube, which will withstand higher temperatures and greater pressures than other standard types of plastic pipe and is competitive in price with copper pipe. Sizes offered for chemical plant use are ⅜-inch to 1½-inches outside diameter, with wall thicknesses from 0.025- to 0.125-inch. Commercial threaded fittings can be used.

The *Valco Corporation*, St. Paul, Minn., has a new line of strong lightweight plastic pipe made of Fiberglas-reënforced polyester and epoxy resins. The 8-inch pipe weighs only 6.5 pounds per foot. These pipes will withstand hot acids and alkalies.

Corrosion-resistant Fan.—A new fan produced by *Du Verre, Inc.*, Buffalo, N. Y., for handling corrosive fumes and gases, has the housing made of a polyester-bonded glass fiber, and the steel impeller blades and shaft are covered with resin-bonded glass fiber, so that no metal parts are exposed to corrosive fumes. Sizes range from 6- to 24-inch inlet diameters.

Plastic Truck Body.—The new Frigid-Van refrigerated trucks for frozen-food delivery, developed by the *Heil Corporation*, Milwaukee, Wis., have a one-piece molded plastic body. The structure has the two protective faces made of glass-fiber-reënforced plastic with the insulation inside, forming a sandwich construction. The low thermal conductivity of the glass laminate permits use of only half the normal thickness of insulation. The 12-foot body weighs only 2,100 pounds, and is designed for a payload of 12,000 pounds. Color is incorporated in the plastic, and no maintenance painting is ever needed.

New Synthetic Fabrics.—The *Air Research and Development Command* has developed a lightweight coated fabric, called Dacralon, that weighs only 7.5 ounces per yard, has high strength and durability, is resistant to sunlight and ozone aging, and remains flexible in Arctic weather. The fabric is Dacron, with the outside coated with 3 to 3½ ounces per yard of Hypalon (chlorinated sulphonated polyethylene), and the underside coated with 1 to 1¼ ounces. The breaking strength is forty-five pounds per inch. *Connecticut Hard Rubber Company*, New Haven, Conn., has developed two coated fabrics that will withstand temperatures of 400 and 480 degrees Fahrenheit. One is a Dacron fabric coated with Kel-F fluorocarbon plastic, and the other is a glass fabric coated with Kel-F. Both are highly resistant to corrosive chemicals.

Silicone Rubber Vulcanized.—*Western Electric Company* has a new process for vulcanizing silicone rubber by means of a 2-million-volt electron stream. The rubber is vulcanized almost instantly, compared with a requirement of several hours for chemical vulcanization. A further advantage is that the product is free of vulcanizing chemicals, which sometimes give undesirable properties to the rubber.

New Magnesium Capacity.—A plant to produce magnesium metal by the ferro-silicon process is being set up by the *Alabama Metallurgical Corporation*, Mont-

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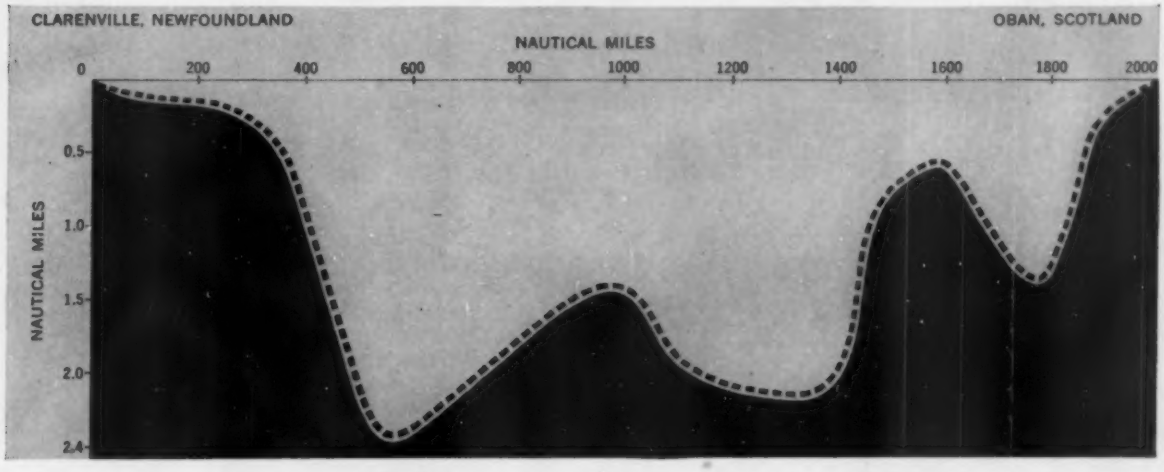


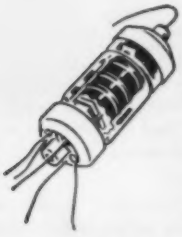
Contour of ocean bed where cable swiftly and clearly carries 36 conversations simultaneously. This is deep-sea part of system — a joint enterprise of the American Telephone and Telegraph Company, British Post Office and Canadian Overseas Telecommunications Corporation.

A great new telephone cable now links North America and Europe—the first transoceanic cable to carry voices.

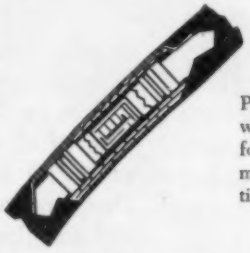
To make possible this historic forward step in world communications, Bell Laboratories scientists and engineers had to solve formidable new problems never encountered with previous cables, which carry only telegraph signals.

To transmit voices clearly demanded a much wider frequency band and efficient ways of overcoming huge attenuation losses over its more than 2000-mile span. The complex electronic apparatus must withstand the tremendous pressures and stresses encountered on the ocean floor, far beyond adjustment or servicing for years to come.

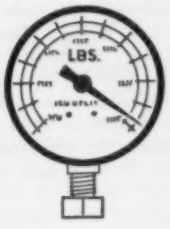
Here are a few of the key developments that made this unique achievement possible:



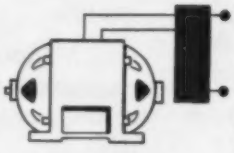
More than 300 electron tubes of unrivaled endurance operate continuously, energized by current sent from land.



Precisely designed equalizing networks and amplifiers compensate for the loss in the cable every 40 miles and produce a communication highway 144 kc. wide.



A unique triple watertight seal protects the amplifiers from pressures as high as 6500 pounds per square inch.



Power supplies of exceptional reliability send precisely regulated current along the same coaxial that carries your voice to energize the amplifying units.

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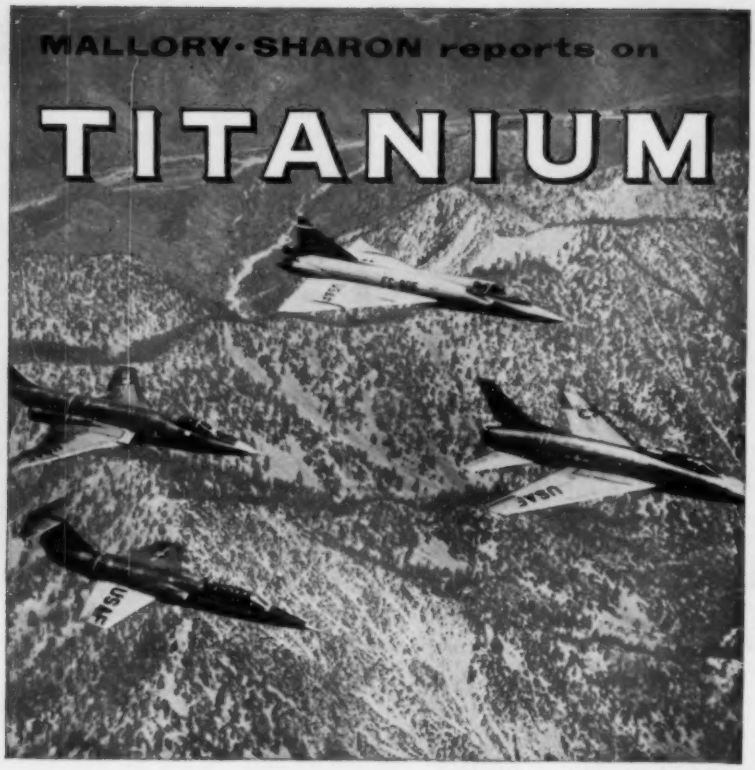

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MALLORY Ti SHARON

Materials Progress (Contd.)

gomery, Ala. The ferrosilicon reacts with calcined dolomite at about 2,120 degrees Fahrenheit. The magnesium is distilled off, condensed, and melted with a flux and cast into ingots. The calcium can be recovered. The process is more costly at present than the conventional method of obtaining the metal from sea water, but the magnesium is purer.

Dow Chemical Company is also enlarging the capacity of its magnesium plant at Freeport, Tex., to add another ten per cent to its production. After World War II, magnesium consumption dropped down to a low in 1946. Civilian products manufacturers had little experience in its use. There was a peak production in 1952 when the Government was buying for the stockpile, but there was another precipitate drop when the Government stopped buying. Consumption is now showing a healthy rise, and more than fifty per cent is going into civilian products. Not more than 12,000 tons annually are being used for the reduction of titanium and zirconium.

Titanium.—For use in chemical plants to withstand 60 per cent nitric acid vapors at 195 degrees Centigrade, the *Youngstown Welding & Engineering Company* is producing commercially pure titanium piping. The 4-inch pipe will take a pressure of 450 pounds per square inch. After more than a year's continuous exposure to these hot acid vapors no appreciable corrosion wear was observed. *Kennecott Copper Company* plans to build a plant at Niagara Falls for the production of a pure grade of titanium metal by a new continuous thermal reduction process. The ilmenite will be reduced with coke to titanium carbide in an electric furnace, and the carbide will be converted in another furnace with iodine gas to titanium tetra-iodide. In a third furnace step, the iodide is dissociated to titanium metal, and the iodine recovered.

Quebracho.—Quebracho, rated after World War II as an important strategic stockpile material, has now dropped to a dubious second-rate importance. The tree is found in commercial quantities only along the west banks of the Parana and Paraguay Rivers, but is so plentiful that it is estimated that 300,000 tons of extract could be produced annually indefinitely without reforestation. High prices and sales restrictions by the Argentine Government have led to greater use of other tannins and the use of chemical substitutes for oil-well mud control. Output has dropped to less than 150,000 tons, about half what it was after World War II.

New Jellying Soap.—The *Army Chemical Corps* has developed a new aluminum

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Materials Progress (Contd.)

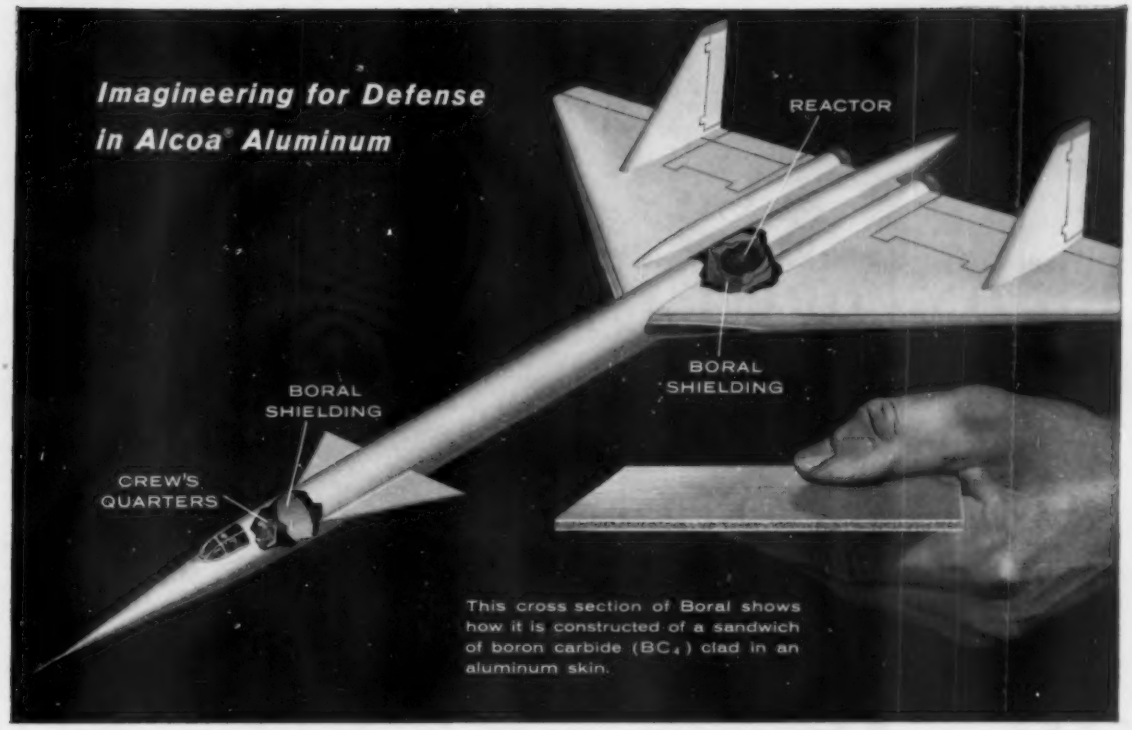
soap with isooctanic acid derived from petroleum. For jellying gasoline for bombs and flame throwers, it will replace the naphthenic acid soaps made with imported coconut oil. This may be another step in the elimination of coconut oil as a strategic stockpile material, which was high on the allocation list during World War II. Lauryl alcohol is now made synthetically, and coconut oil is no longer needed as a source of lauric acid. During the war large quantities of coconut oil were allocated to the soap manufacturers in order to obtain the by-product glycerin, but ample quantities of glycerin are now made synthetically. Soap has been fast losing its importance as a detergent, and coconut oil has attraction only in specialty toilet soaps and shampoos.

Detergents.—In the short space of a decade, synthetics have taken close to 65 per cent of the detergent market. Synthetic detergents, largely derived from petroleum, reached a production of 2,320 million pounds in 1955, and will exceed this total in 1956, while soap use has been dropping off. Originally largely limited to industrial cleansers, about seventy-five per cent of the detergents are now going into household use. Brand-named toilet soaps now constitute much of the soap sales, but synthetic detergents in bar form are appearing.

V-4 Automotive Engine.—*American Motors Corporation* has designed a new air-cooled 62-horsepower V-4 automotive engine weighing only 200 pounds, of which 70 pounds is aluminum. The cylinders are die-cast aluminum with the bores chromium plated. The crankcase, cylinder heads, and timing-gear housings, are also die-cast aluminum. The engine is designed for powering airborne military vehicles, but is also suitable for use in light passenger automobiles. The American Die Casting Institute states that 117 million pounds of aluminum die-cast parts were furnished by die casters to the automobile industry in 1955. Parts include torque converter housings, transmission extensions, valve body assemblies of automatic transmissions, engine valve bodies, and steering assembly components.

Aluminum Stacks.—Two new 564-foot Matson Line luxury liners, MARIPOSA and MONTEREY, showed savings of 15 tons each in superstructure weight by having the stacks of aluminum instead of the conventional steel. The stacks are made of ¼-inch plates of Kaiser 6061-T6 alloy. The reduced superstructure weight lowers the center of gravity, giving greater stability to the ships. The work was done by the *Willamette Iron & Steel Company*.

Aluminum and Copper Cables.—Ever since a TVA order for transmission cable



New Alcoa Boral stops neutrons 100 times better than concrete

The high neutron density from the reactor represents a very real danger to the crew of an atom-powered plane. Since it is impossible to get very far away from the source of the radiation, effective shielding must be used to block neutrons. Yet shielding is either very bulky and heavy, as in the case of dense concrete, or heavy and expensive, as in the case of lead.

A lightweight neutron shielding material developed by the Atomic Energy Commission may prove to be an effective solution to the problem. It is known as Boral from its principal ingredients, boron carbide and aluminum. Boral has 100 times the shielding effectiveness of dense concrete. A plate only ¼ in. thick stops more high-speed neutrons than two feet of solid concrete.

In response to AEC's invitation to commercial producers, Alcoa has developed a fabricating procedure that provides Boral plate and sheet in the largest sizes ever offered. It is made in thicknesses of ⅛ in. and ¼ in.; sizes 48 in. x 120 in. and 36 in. x 96 in.; annealed or "as-fabricated" tempers.

While Boral is ideal for mobile reactors such as those used in the Nautilus or in aircraft, it can be used anywhere that space and weight limitations are critical. It is already in use or planned for atomic power and research reactors of many types. It makes possible far more compact and workable designs.

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Materials Progress (Contd.)

was split fifty-fifty between copper and aluminum, there has been much discussion of the relative merits of the two metals for such purpose. Now, the *Pacific Gas & Electric Company* is removing the six 142-mile copper power line cables from the Pit River hydroelectric plant in Shasta County, Calif., and replacing them with aluminum cables. The company believes that greater efficiency of the aluminum cables, plus the high salvage value of the 7,000,000 pounds of copper to be replaced by 4,000,000 pounds of aluminum, will more than pay the replacement costs which include replacing the 9-foot tower arms with 12-foot arms to give more free swing room for the aluminum cables.

All-aluminum Truck Trailer.—The *Perfection Steel Body Company*, Galion, Ohio, has built its first all-aluminum dump truck trailer for handling sand and gravel. The body, 20 feet long, 8 feet wide, and 4 feet high, is constructed of 3/16-inch aluminum alloy 5154-H32 sheet welded together by the inert-gas consumable-electrode method. The aluminum body saves 2,000 pounds of dead weight, resulting in an added ton of payload. No painting is necessary.

Oil from Shale.—A Swedish process will be utilized in a new plant of the *Oil Shale Corporation* near De Beque, Colo., for producing oils and gasoline from shale. The method consists in tumbling the shale in an airtight mill with steel or aluminum oxide balls heated to 1,000 degrees Fahrenheit. A ton of shale yields 29 pounds of gas of 725 Btu per cubic foot.

Germanium rectifiers.—A new line of oil-immersed germanium rectifiers, rated at 300 to 50,000 amperes at 24 volts, has been announced by the *Rapid Electric Company*, New York, N. Y. The germanium junctions are hermetically sealed, and pushbuttons on the housing operate a motor to raise or lower the output.

Heat-resistant Paint.—A new Alumicone heat-resistant paint being produced by *Ateck, Inc.*, Toledo, Ohio, for aircraft exhausts, furnaces, stacks, and ducts, will withstand temperatures to 1,500 degrees Fahrenheit without deterioration. It is based on a silicone-alkyd resin with aluminum flake pigment, and it can be brushed or sprayed on without a primer.

New Primer.—A new phosphate primer that can be used on rusty iron or steel surfaces after a simple removal of loose rust scale by wire brushing is being marketed by the *Rusticide Products Company*, Cleveland, Ohio, under the name of Ospho. It converts the iron oxide of the residual rust to an iron phosphate and assures a good bond for paints.

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ROCKETS AND GUIDED MISSILES

Alfred J. Zaehringer

Astronautics.—Additional details on the actual U. S. satellite have been revealed. The satellite will take the form of a highly polished magnesium alloy sphere. Brooks & Perkins, Detroit, Mich., magnesium fabricators, will build about thirty-five of the mirrorlike spheres for the 1957 *Vanguard* program.

The magnesium sphere will be twenty inches in diameter and will weigh four pounds empty. Each sphere will house instruments, radio and power supply, and exterior antennae. The sphere will ride to its space position on the head of a 3-stage rocket.

Recently the United States has asked the aid of South American countries in tracking the satellite. The U. S. wishes to establish optical tracking stations at White Sands and Cocoa Beach in the States, and either the Dutch West Indies or Venezuela, and at Quito (Ecuador), Antofagasta (Chile), Cordoba (Argentina), Bloemfontein (South Africa), and at undisclosed sites in Australia, Hawaii, Southern Japan, India or Pakistan, Egypt, and Southern Spain or Morocco.

In addition, radio stations will be located at: Santiago, Antofagasta, Lima, Quito, Panama, Antigua, British West Indies; Havana, Jacksonville, Fla.; Washington, D. C.; and San Diego, Calif.

A fourth rocket will be used in the *Vanguard* 3-stage satellite rocket. Atlantic Research Corporation, Alexandria, Va., will build a small solid-propellant rocket to spin-stabilize the third-stage.

Meanwhile, astronautics is moving into the commercial phase. Convair recently announced construction of a new $40-million facility to be known as Convair-Astronautics. Completion date is 1957. The new division will build the *Atlas* ICBM but will also devote a portion of its activities to the engineering phases of high-altitude and space flight.

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MARKEM ...TO MAKE YOUR MARK

Missiles.—Two of the "big guns" in the U. S. missile spectrum are rapidly nearing the operational phase. The *Atlas* ICBM is getting a huge production facility. The Convair-operated U.S.A.F. facility is to be located near San Diego, Calif. North American Aviation is currently running static tests of a prototype missile. One *Atlas* is said now to cost about $1.5 million. In addition, launching facilities for the 5,000-mile-range intercontinental ballistic missile are being established at Patrick Air Force Base, Fla.

Recently the U. S. Government concluded all arrangements, clearing the way for a 5,000-mile missile test range which extends into the Atlantic Ocean from Florida to the British Ascension-St. Helena Island group.

In the intermediate-range category, Chrysler Corporation is getting ready to turn out the *Jupiter* 1,500-mile-range missile. The present *Redstone* 200-mile missile is said to be a prototype for the larger liquid-fueled *Jupiter C*. There has also been mention of a possible solid-propellant version, *Jupiter B*.

The IRBM is being developed under Army-Navy auspices. Aim of the program is to develop a missile which can be fired from ships against land targets. The *Jupiter* would thus greatly extend the fleet missile striking power. Presently, the Navy *Regulus*, with a range of about 500 miles, is the naval big stick.

The Army, too, is strengthening its missile arm. A newer, more effective *Nike* with a range of about seventy-five miles is said to be near. This comes at a time when *Nike* is expected to compete in effectiveness tests against the ramjet-propelled U.S.A.F. *Talos* missile.

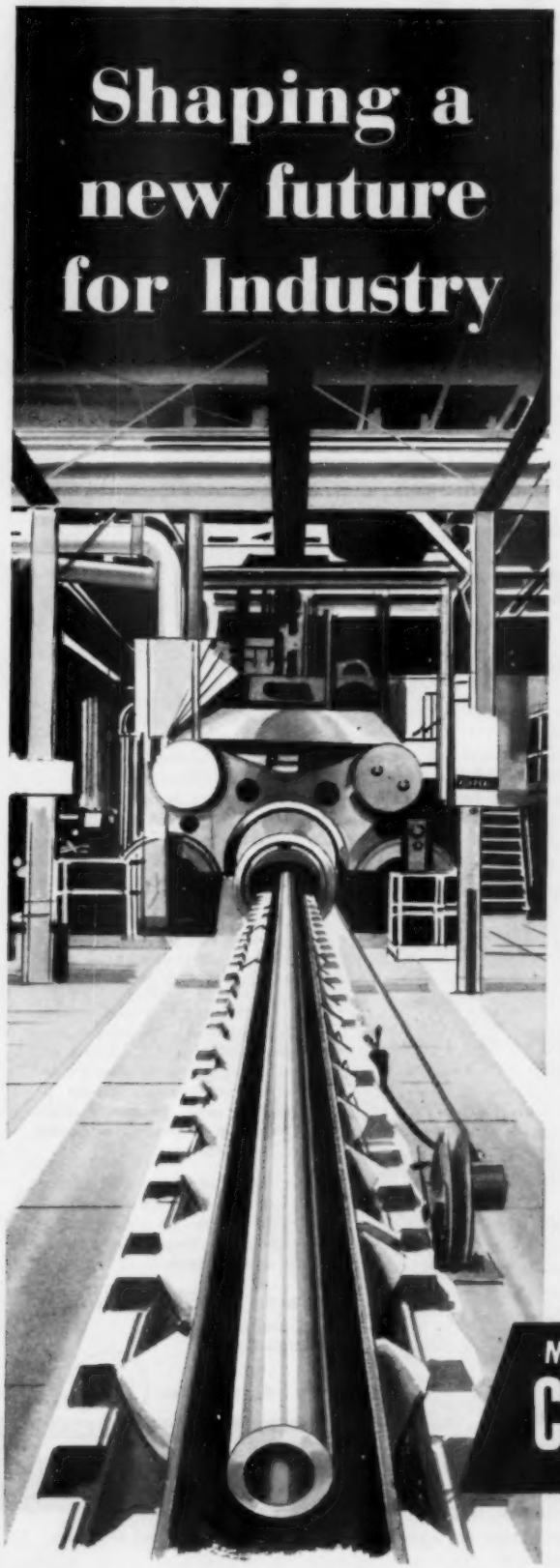
Latest Army missile to be unveiled is the *Dart* antitank weapon. This Army Ordnance missile was developed by the Aerophysics Development Corporation (a subsidiary of Curtiss-Wright Corporation) of Santa Barbara, Calif. Production of *Dart* will be by another Curtiss-Wright subsidiary, the Utica-Bend Corporation, under a $16-million contract at a Utica, Mich., facility.

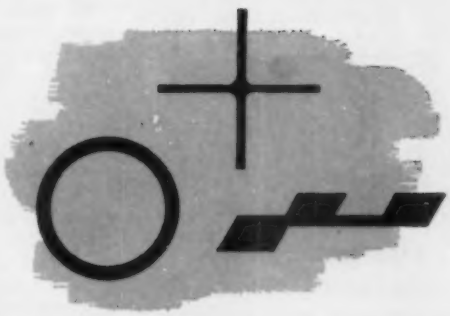
Dart is propelled by a solid-fuel rocket motor, is launched from a vehicle, and is guided by means of trailing wires. Range is about 2,000 yards.

The Army's *Nike* booster has been coupled with the *Deacon* rocket to form an effective research tool. Slated for use in International Geophysical Year tests, the 2-stage rocket can reach altitudes of about 100 miles.

Meanwhile, the Air Force *Falcon* missile is being used to arm the F-89H interceptor. Each F-89H will carry six *Falcon* rockets plus forty-two *Mighty Mouse* rockets. It is said that the F-102 delta-winged interceptor will be all-*Falcon* armed. (*Continued on p. 484*)

Shaping a new future for Industry





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Rockets and Guided Missiles

The Research Scene.—Two new high-speed research projects have been reported. University of Utah scientists have fired projectiles at a speed of over two miles a second. Conducted in underground concrete tunnels near Salt Lake City, the group hopes to trigger a hydrogen explosion to produce velocities of over five miles a second.

Navy Ordnance has fired missiles at speeds of 7,000 miles an hour in a super-velocity gun. The golf-ball-sized missiles are being tested by the Aëroballistics Research Department at White Oak, Md. The gun uses pressurized helium as a propellant with a boost coming from the high-pressure burning of hydrogen and oxygen.

Production and reduction of missile heat are the topics of two other research projects. McDonnell Aircraft Corporation, St. Louis, Mo., has been simulating the heating of missiles by using radiant heat generated by quartz lamps and reflectors. Skin temperatures of 1,000 to 1,500 degrees Fahrenheit already have been produced.

In the heat-reduction tests, Aerojet-General Corporation has been studying the temperature-depressing effects of certain chemicals. In one case the Aerojet group found that they could lower exhaust temperatures from 400 to 120 degrees Fahrenheit. Materials found effective are potassium nitrate, potassium nitrite, sodium nitrate, and liquid bromine.

The U.S.A.F. *Smart* (supersonic military air research track) facility has already hit speeds of Mach 1.25. Solid- and liquid-propellant rockets have been used to push sleds on the 12,000-foot-long track located atop Hurricane Mesa, Utah. The track terminates at the edge of a 1,500-foot cliff. At this point the rocket pusher sleds are stopped by a combination of water scoop, reverse-firing rockets, and mechanical arrestors.

The test sled, however, goes over the cliff and is used for testing safety equipment. Over fifty runs have already been made, and the aim is to attain a speed of Mach 2 this year.

Ejection of chemicals from missiles as a tracking aid is being studied by A. D. Little, Inc. Two materials have been mentioned: hydrogen peroxide and phosphorous.

The advent of "chemical-fuel" jet aircraft also poses new problems of exhaust streams. Compounds being considered to increase the performance of conventional fuels (such as the hydrocarbons) are the light metals and metallo-organic compounds (such as alkyl boranes, etc.). Removing the solid particles of combustion of such compounds from engine parts and also from the exhaust stream is now the subject of much attention.

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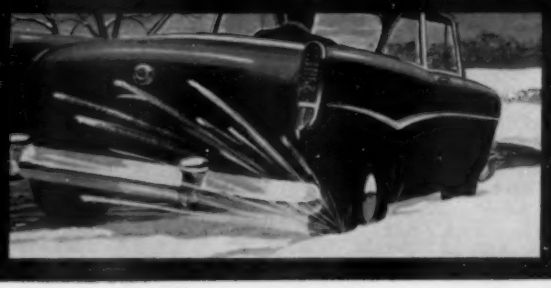

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The Thornton POWR-LOK principle is another in the ever-growing list of safety- and power-transmission innovations developed by Dana engineers and Dana resources. It is a new concept of controlled driving-wheel power . . . the most revolutionary rear axle design in volume production since the invention of the differential itself!

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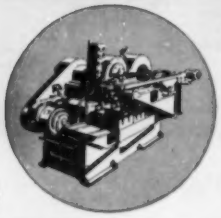

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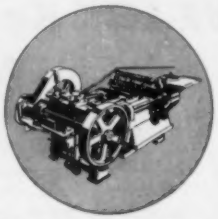

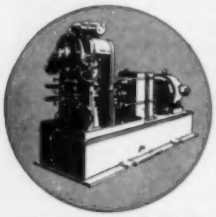

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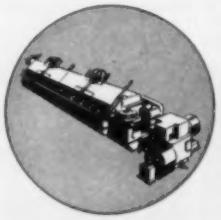

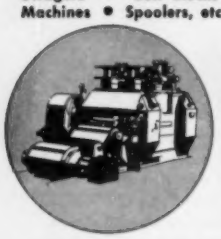

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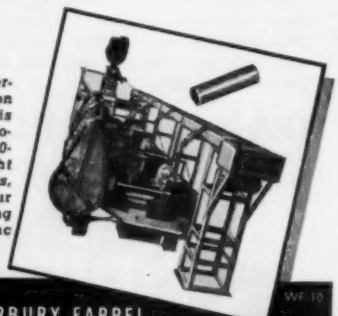

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ARMAMENT ELECTRONICS

Dr. W. S. Carlson

GROUND-BASED pulsed radars are employed in both military and commercial applications to locate and track aircraft. Surveillance and precision approach radars of the ground-controlled approach airport traffic control system are functional counterparts of acquisition and track radars in an antiaircraft fire-control system.

In these applications, detection and tracking performance may be impaired at low elevation angles because of ground clutter. Reflections from tall structures and natural features of the terrain may mask returns from targets of interest. Interference due to ground clutter can be ameliorated by favorable siting of the equipment and by appropriate choice of radar parameters.

Assuming clutter to consist of discrete objects distributed more or less at random with respect to range and bearing, the aggregate reflecting area contributing at any instant to the received signal depends on beam width and pulse length. As long as the individual reflecting elements comprising clutter are small compared with the dimensions of the transmitted pulse packet, changes in beam width do not affect the product of illumination and aggregate reflecting area.

For a given average power, the energy per pulse incident on a single reflecting element is independent of pulse length. However, the number of elements contributing simultaneously to the clutter signal varies directly with pulse length.

It follows, therefore, that the relative contribution made by any single reflecting object to the received signal varies inversely with beam width and pulse length. Reduction of beam width and pulse duration enhances return from a target of interest relative to return from other objects.

A short pulse yields good discrimination in range but implies high peak power and imposes severe demands on receiver performance. A narrow beam favors resolution in bearing but implies a large antenna structure or adoption of a high radio frequency. Unfortunately, atmospheric attenuation and precipitation clutter make operation at frequencies above X-band (5,200-11,000 mc) unattractive except for short-range applications.

A radar developed for observation and control of airport surface traffic has recently been described which provides a good example of equipment designed primarily for high resolution. Principal characteristics are as follows:

Frequency, 24,000 mc (1.25 cm); pulse length, .02 μs; repetition rate, 14,400 p/s; peak power, > 30 kw; i-f pass band, 80-180 mc; beam width—azimuth, 0.25-degree, and elevation coverage, 0 to −25 degrees $\csc^2$ fan for antenna height of 100 ft.; antenna—area, 12 x 4 ft.^{2} and scan rate, 60 r/m; indicator—type, PPI; radius, 8 in.; scale, ½-3 mi/radius; resolution, 500 lines/radius.

To take full advantage of the range resolution afforded by an .02 μs pulse requires a receiver band width > 50 mc. To attain this result an i-f amplifier was designed consisting of a low noise triode followed by 9 stages of distributed amplification. Each distributed amplifier stage uses 6 tubes. The 0.25-degree azimuth beam width represents about 25 feet at one mile. The radar resolution volume is therefore smaller, at ranges of practical interest, than the aircraft under observation.

With this equipment advantage can be taken of a difference in reflectivity between a target and its background (*e.g.*, an aircraft on a runway) to form a crude image of the target on an intensity-modulated indicator. Given a favorable viewing aspect,

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Silicone Dielectrics

ELECTRICAL AND ELECTRONIC NEWS No. 8

SILICONE DIELECTRIC COMPOUND LUBRICATES, STOPS CORROSION

A silicone dielectric compound, Dow Corning 5 is growing in popularity for a wide variety of industrial and public utility applications. That's because the compound possesses excellent water repellency and corrosion resistance in addition to its superior dielectric properties.

A leading public utility company reports a thin film of Dow Corning 5 on insulators reduces electrical leakage to a new minimum by preventing the formation of continuous, conducting moisture films.

Furthermore, the film maintains high surface resistivity despite heavy contamination by air-borne fly ash, cement dust and earth particles. Its effectiveness appears to persist without maintenance for many years.

Non-melting and grease-like, Dow Corning 5 is also an effective, long lasting lubricant for switches, meters, condensers, recorders and similar mechanisms. It maintains lubricity at temperatures ranging from —100 to over 300 F and resists moisture, oxidation, salt spray and chemical attack.

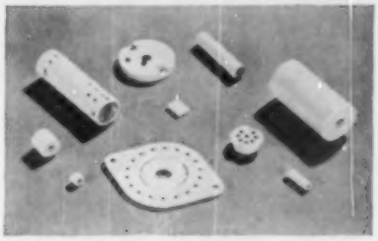
A convincing demonstration of the versatility of Dow Corning 5 is provided by Col. K. C. Brown (USAR Ret.) who reports that the silicone compound has stopped salt water corrosion of the tackle blocks, brass and copper fittings, electrical connectors and battery terminals on his ocean-going ship "Sou'Wester". In the Colonel's words, "The results far exceed expectations. Fittings and connections show no sign of corrosion; terminals are electrically efficient." *No. 31*

Silicone Coating Cuts Cost of Ceramic Electrical Insulators

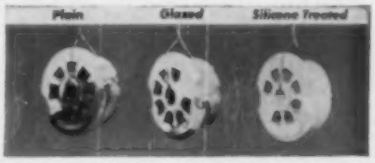
Imaginative use of new materials frequently enables designers to create a competitive sales advantage while cutting production costs. Here's a case in point from Centralab Division of Globe-Union Co., Milwaukee.

Centralab reports that a silicone treatment is rapidly replacing conventional glaze coatings on ceramic electrical insulators. Production savings with the silicone treatment range as high as several dollars per thousand units, permitting Centralab to quote competitively for ceramic against ordinary plastic molding materials.

The new treatment consists simply of a dip in Dow Corning 200 Fluid followed by a short baking cycle, contrasted to the costly individual air-brushing and high temperature kiln-firing required for a glazed surface. The silicone treatment gives equivalent or better moisture resistance and surface resistivity for all but the highest frequency applications.



Centralab now offers the silicone treatment on its entire line of steatite-ceramic parts including insulators, capacitor bodies, rotary switches and trimmers. Silicones have become such a strong selling point that, as a Centralab spokesman puts it, "Our sales department reviews every order or quotation request calling for glaze and recommends the silicone treatment where ever possible." *No. 34*



Greater moisture repellency of silicone treated ceramic tube socket is demonstrated by dunk test using colored water.

New Silicone Bonded Mica Tape More Flexible, Easier to Handle

Mica Coated Products Co., Salem, Mass., has developed an improved Class H insulating material comprised of a thin coating of ground mica bonded to glass cloth with Dow Corning 994 Varnish.

According to the manufacturer, this new combination provides greater dielectric strength and heat resistance than possible with silicone-glass alone. In addition, it has far greater flexibility than conventional tapes made with mica-splittings. A 5-mil thickness of it may be wrapped around a 1/32" mandrel without harm.

This new material is unusually uniform in gage, finish and dielectric strength. Since it is neither tacky or slippery, there is no danger of its welding together or blocking when guillotine-cut.

The flexibility of Dow Corning 994 Varnish and its compatibility with mica led to its use as the binder for ground mica coating on two other new tapes by Mica Coated Products Co.: an alkyd resin dipped glass cloth for temperatures up to 170 C; and Mylar, for Class B applications. The silicone-mica combination gives both tapes appreciably greater resistance to fire and arcing. *No. 32*

Silicone-Glass Laminates for electrical and mechanical applications are described in new brochure which illustrates parts used in typical industrial applications. Also provides engineering information on silicone-glass laminates and lists fabricators of such laminates. *No. 33*

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principal features of the aircraft silhouette are readily discernible in the image at ranges on the order of 2,000 feet.

HIGH resolution techniques may be to advantage for aërial reconnaissance and for ranging on ground targets. However, there are important applications of radar, such as the air defense and GCA service previously mentioned, in which high resolution may be incompatible with other design objectives.

Alternative methods of coping with clutter have therefore been adopted. In one way or another, relative motion of the target with respect to stationary objects is used to discriminate against clutter.

Consideration of a stationary reflector and a target moving along the line of sight in an otherwise free space situation will illustrate the principle. When the two objects are at the same range, incident and reflected wave trains will be in phase, resulting in mutual reënforcement of the returning echo. When, in consequence of relative motion, the two objects become separated in range by a distance equivalent to a quarter-wavelength at the transmitted frequency, the 2-way path difference represents a relative phase shift of 180 degrees. Reflected wave trains are subject to mutual interference.

Progressive motion of the target with respect to the stationary object results in a progressively increasing phase difference between the reflected wave trains. The composite echo will exhibit periodic variations in amplitude corresponding to cyclic reënforcement and interference.

This phenomenon is readily observed on an A-scope indicator as a periodic variation in height of the video trace. If the moving and stationary objects have equal reflective cross sections then, at a range large compared with their radial separation, the received power will vary between zero and four times the power which could be obtained from a single reflecting object.

Amplitude variation due to interference between reflections from a moving target and stationary objects at the same range has been utilized practically for detection and tracking of aircraft in the presence of clutter. In principle, it is required only to provide a means for comparing range video sweeps on successive pulses and using the difference to control an intensity modulated (PPI) indicator.

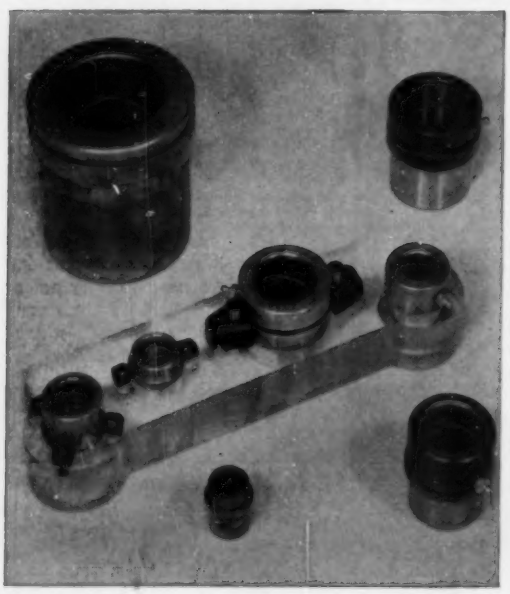
This can be accomplished by a division of the video pulse between direct and delay channels to a subtraction circuit. The difference in transmission time between the two channels is made equal to the interval between successive pulses. Because this interval may be as much as a millisecond it is impractical to use a conventional transmission line in the delay channel. Instead, the video pulse is propagated acoustically through a liquid or solid line.

The subtraction operation can be regarded as a point-by-point comparison between successive video pulses. It is evident that the pulses to be compared must be made temporally coincident in the subtraction circuit if cancellation is to be effected. Displacement in time of one pulse with respect to the other will result in comparison of noncorresponding points of the two time functions, thus impairing cancellation. A difference in gain between the direct and delay channels will also result in imperfect cancellation.

Unfortunately, both the transmission time and gain characteristics of the direct and delay channels are subject to drift. Adjustment is difficult because gain imbalance and timing error produce the same effect in the subtraction circuit.

Because the system operates on amplitude variations due to interference between reflections from a moving target and objects in the clutter, the designation "noncoherent MTI" is often applied. The term "coherent MTI" is applied to systems in which the echo is mixed with a stable reference signal generated in the receiver. The reference signal oscillator is phase-locked to the transmitter.

In the absence of a moving target, out-



How a better precision-fit Guide Pin Bushing* is made in less time with

SHELBY SEAMLESS MECHANICAL TUBING

Here is another manufacturer that is turning out a better product in less time by using Shelby Seamless Steel Tubing.

The product, a wring-fit bushing, makes possible a truly precision die set, which permits closer working tolerances and extends the life of the dies to a degree never before thought possible. The bushing is harder, stronger, more uniform, longer lasting and better fitting.

When Shelby Seamless Tubing is used, no boring is necessary—the hole is already there. It offers more, however, than just a pre-bored hole. It combines to an exceptional degree the qualities of strength, uniformity, and dimensional accuracy. These advantages, coupled with the workability and excellent machining properties of Shelby Seamless, make it the ideal material for critical mechanical applications like this.

Available in a wide range of diameters, wall thicknesses, various shapes and steel analyses, Shelby Seamless Mechanical Tubing is produced to exacting standards by the world's largest manufacturer of tubular steel products. Get in touch with our engineers if you would like help in applying Shelby Seamless to your specifications.

*Manufacturer's name on request.

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ATLAS *Precision Products*

put of a synchronous detector will be constant; *i.e.*, a d-c voltage. As previously noted, wave trains reflected from a moving target will exhibit continuously changing phase.

COHERENT and noncoherent systems impose the same limitations on frequency drift of the transmitter and on frequency modulation during the pulse. For several reasons, including the requirement for a stable local oscillator, coherent MTI entails more complex receiver circuitry. On the other hand, dependence on amplitude rather than phase variation of the clutter signal requires a receiver of considerably greater dynamic range for comparable MTI performance. Moreover, a system which depends on amplitude variations due to interference between echoes from moving and stationary objects will not respond to a moving target in the absence of clutter.

In this connection it should be noted that neither coherent or noncoherent MTI will respond to a target moving at a velocity such that the target travels a distance $\lambda/2$, or multiple thereof. At speeds for which the doppler frequency is a multiple of the pulse-repetition rate either type of MTI system is blind because neither phase nor amplitude variations can be observed.

For this reason it is desirable to have the lowest blind speed exceed the maximum target velocity of interest. This stipulation obviously imposes an important restriction on the choice of r-f frequency and pulse-repetition rate.

In comparing coherent and noncoherent MTI systems, it was stated that the former operates on the changing phase relation between moving target return and output of a reference oscillator. The noncoherent system was said to depend on amplitude variations due to interference between echoes from moving and fixed targets at the same range. In consequence, a limiting receiver which passes only phase information may be used with the coherent system. A linear phase-sensitive detector converts the phase variations to amplitude variations for input to the cancellation circuit.

Unlike the clutter-amplitude variations on which the noncoherent system operates, phase variations are independent of the echo signal level. The delay line and subtraction circuit used with both MTI systems functions as a high-pass filter. Both types of MTI may be regarded as auxiliary features of an otherwise conventional pulsed radar. Pulse-to-pulse comparison does not afford sufficient rejection to cope with return from massive clutter which may be 60 db or more above the target echo. Development of so-called pulsed doppler systems has therefore been vigorously pursued.

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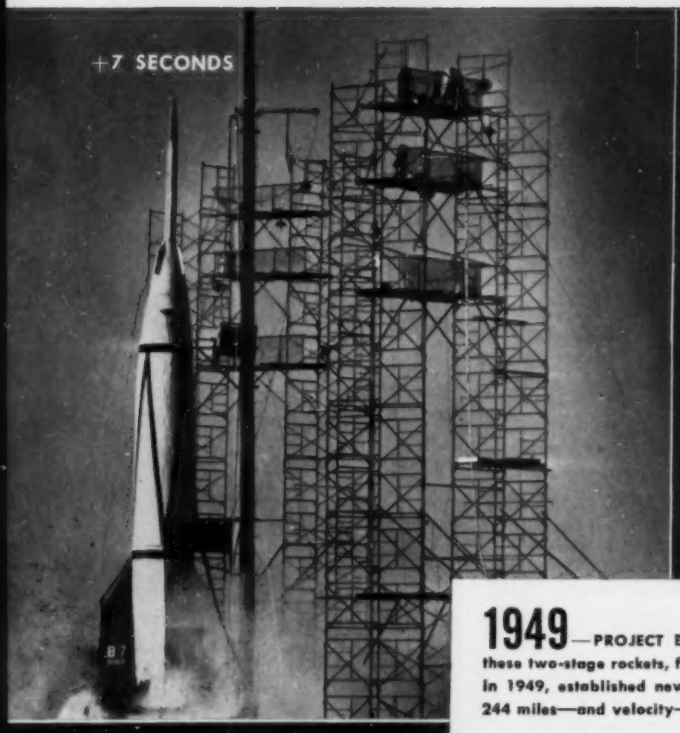
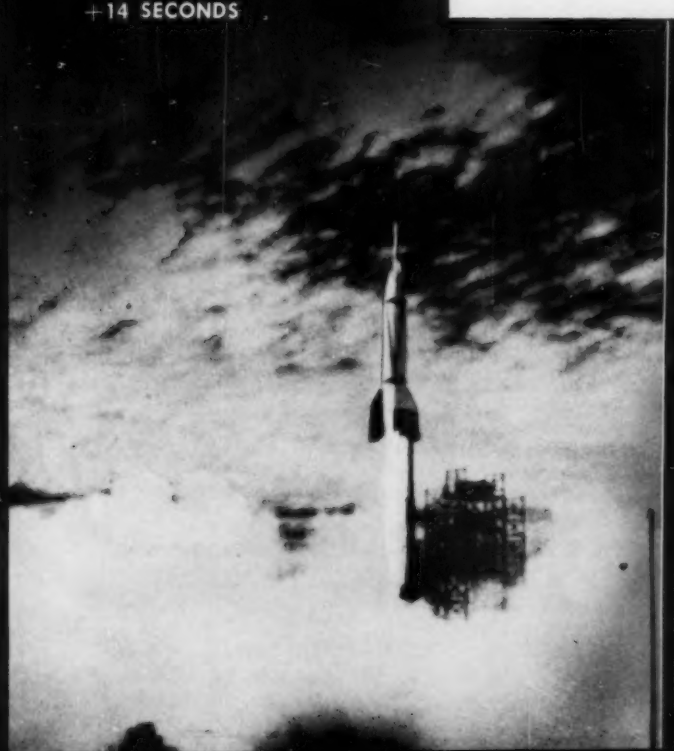


1949—PROJECT BUMPER—The fifth of these two-stage rockets, fired by General Electric in 1949, established new records of altitude—244 miles—and velocity—5150 mph.



Advances Missile Technology

General Electric's Project Bumper established new records of altitude and velocity. But far more important is the valuable research data compiled in the successful completion of the Bumper project. Many problems were overcome with Bumper—problems in temperature, telemetry, separation, and aerodynamics. Bumper helped solve the problems of communicating with missiles at extreme altitudes, and was a major preliminary step in the development of a satellite. In solving these and other problems, General Electric has contributed a wealth of research data to the missile industry—information that is being utilized on the nation's top priority ballistic missile project.

General Electric's Special Defense Projects Department presently is working on an Air Force prime contract to develop the ICBM nose cone. Programs are being carried out in such varied fields as communications, hypersonics, metallurgy, mathematics, and thermodynamics to support this nose cone contract.

General Electric has formed the Special Defense Projects Department to act as a Company focal point for large, highly complex missile projects. Scientists in the new department, backed up by the vast resources of many General Electric operating departments and laboratories, are currently working to solve the perplexing problems associated with the ICBM nose cone and other missile projects.

By focusing this wide range of specialized talents of General Electric personnel on highly complex defense system problems, the Special Defense Projects Department is making significant contributions to America's defense program. Section 224-5, General Electric Co., Schenectady 5, N. Y.

ENGINEERS: G.E.'s Special Defense Projects Department is currently expanding its staff of highly skilled engineers and scientists. If you have a background of successful creative engineering, send your qualifications to: Mr. George Metcalf, General Manager, Special Defense Projects Department, General Electric Co., 3198 Chestnut St., Philadelphia, Pa.

TODAY—**CONTINUED RESEARCH AND EXPERIMENTATION in advanced missiles and missile systems is helping solve such advanced problems as development of the ICBM nose cone. Headquarters for General Electric's participation in these programs is the Special Defense Projects Department in Philadelphia, Pa.**

MR. ROBERT P. HAVILAND, Flight Test Engineer at SDPD, directed Project Bumper and other advanced programs, gaining valuable experience which he is currently applying to present missile programs.

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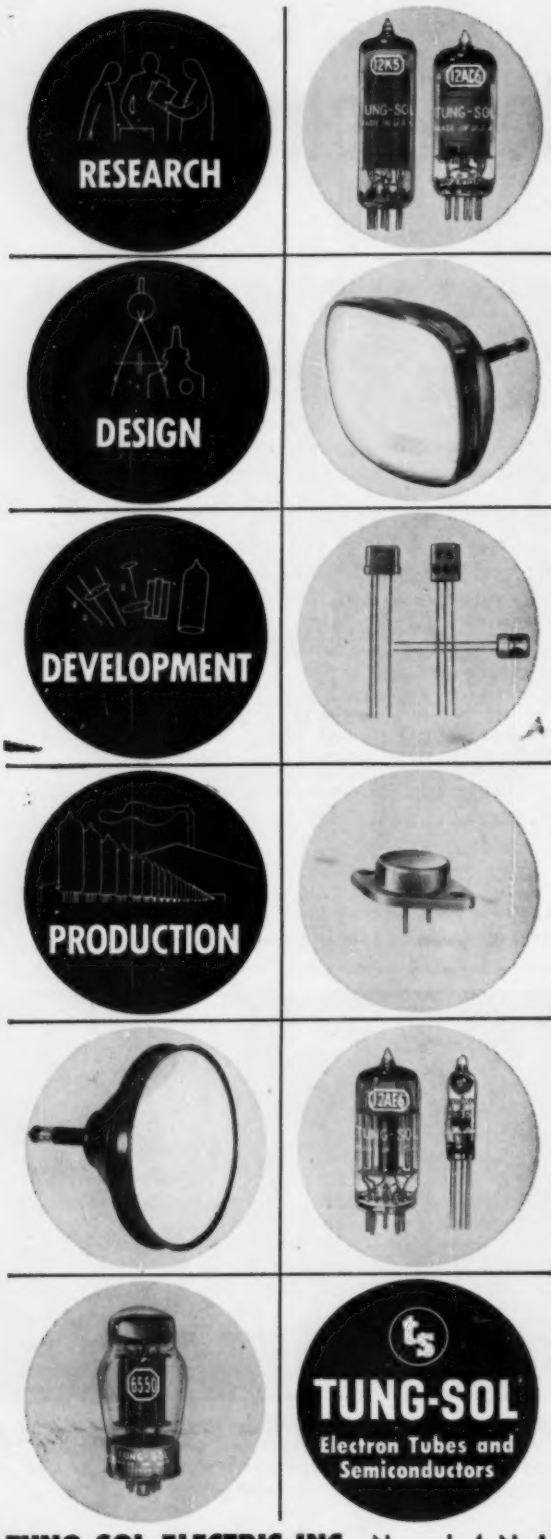

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RECENT PATENTS

This department on recent military-industrial patents is being published in ORDNANCE *to keep our readers informed of the latest developments in these fields. The data are compiled by Melvin Nord, patent attorney, Detroit, Mich. Copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents each.*—THE EDITORS.

Apparatus for Beaching Seaplanes.—*U. S. Patent No. 2,743,697. Issued May 1, 1956, to Henry G. Cooper and Merton H. Dickinson:* This patent provides apparatus for beaching

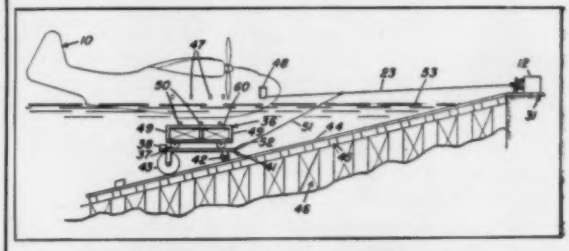

Fig. 1. Seaplane beaching mechanism.

seaplanes in which a buoyed cable is used to limit and prescribe the motion of the plane while its own propellers are urging it forward to a desired position with respect to a cradle car. The apparatus is shown in Figure 1.

Torpedo Depth Control.—*U. S. Patent No. 2,744,485. Issued May 8, 1956, to Horace E. Karig. Assigned to the Secretary of the Navy:* Torpedo depth control is accomplished in this patent by high-pressure hydrostatic control of the rudder. Changes in depth are sensed by a metal bellows the outside of which is exposed to sea-water pressure, the inside being under vacuum. A change in extension of the bellows causes a vertical pendulum to tilt. The pendulum also tilts if the torpedo is at any time inclined away from the horizontal. The rotation of the pendulum opens or closes orifices, thereby varying the hydrostatic pressure which operates the rudder. When the correct depth is reached, the torpedo automatically levels off.

Self-Projected Missiles.—*U. S. Patent No. 2,745,347. Issued May 5, 1956, to Alexander Lightbody and James M. Johnston. Assigned to Sir W. G. Armstrong, Whitworth Aircraft, Ltd.:* This patent describes a self-projected missile having "wrapped-around" boost motors to provide acceleration during the initial stage of the flight for a few seconds prior to their being discarded. The object of the invention is to ensure that all the boost motors will be simultaneously discarded without damaging the missile or causing deviations in its course. U. S. Patent No. 2,748,703, issued June 5, 1956, to Wilbur H. Goss and David A. Washburn and assigned to the Secretary of the Navy, also describes a similar invention.

Missile-Resistant Garment.—*U. S. Patent No. 2,748,391. Issued June 5, 1956, to Frederick J. Lewis, Jr., and John F. Quinlan. Assigned to Secretary of the Navy:* In present-day

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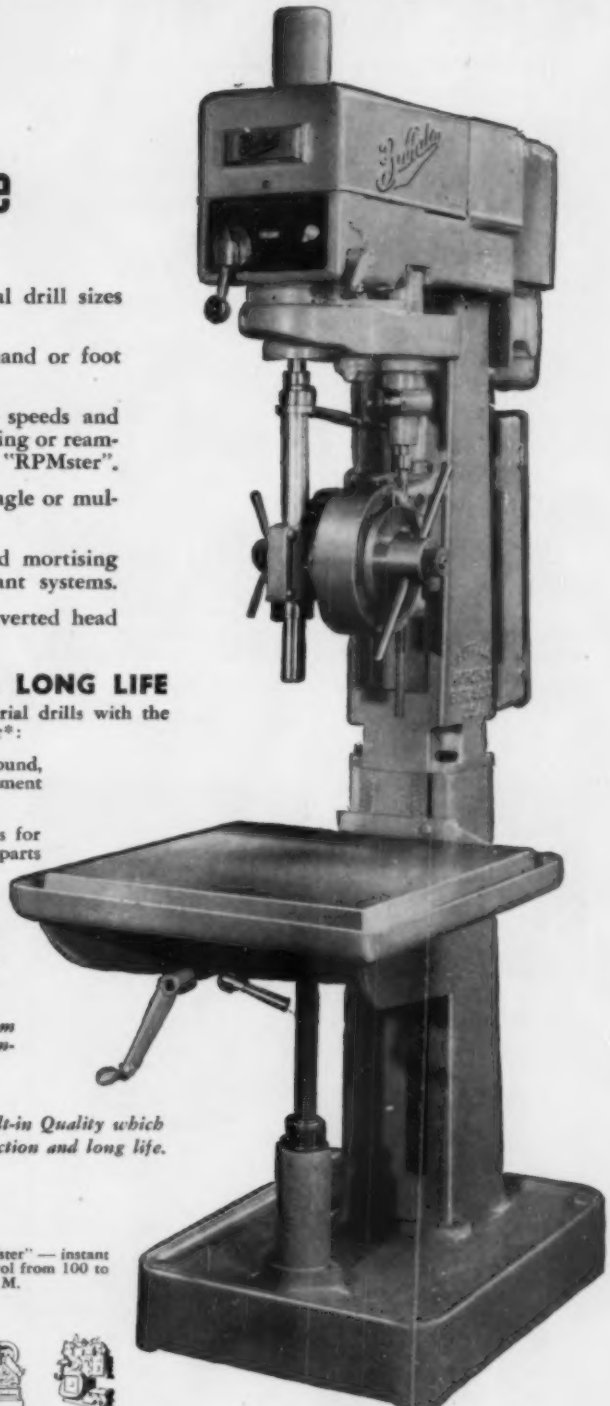

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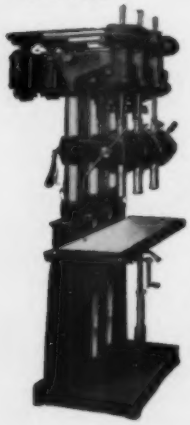

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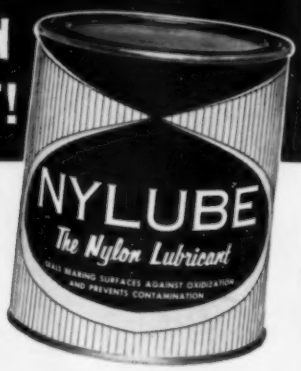

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Recent Patents (Contd.)

warfare, approximately seventy per cent of all combat casualties are caused by uncontrolled missiles; *i.e.*, fragments from grenades, mortars, and artillery. The present invention provides a lightweight armored vest which serves to stop such fragments. It consists of a number of rigid curved panels consisting of molded slabs of laminated plastic, the panels being flexibly connected together. Each panel contains twelve to twenty layers of fiber glass, each impregnated with a liquid resin and then molded together. The panels are arranged in "pockets" and overlap each other at all times, regardless of whether the wearer is standing or kneeling.

Aircraft Jet Propulsion.—*U. S. Patent No. 2,747,363. Issued May 29, 1956, to Harvey Cohen and John H. Darth. Assigned to Power Jets (Research and Development) Ltd.:* This invention provides a means of controlling "reheat" or "afterburning" by burning additional fuel in the jet pipe. When additional fuel is burned in the exhaust duct, an increased back pressure is exerted on the gas-turbine drive, and there is a serious risk of overheating. This is avoided in the present invention by automatically increasing the opening of a variable-area nozzle at the end of the exhaust duct as the fuel supply to the afterburner is increased. This is shown in Figure 2.

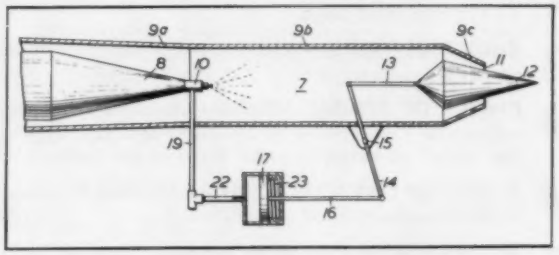

Fig. 2. Variable area nozzle device.

Impact Fuze.—*U. S. Patent No. 2,748,705. Issued June 5, 1956, to Frank B. Hale. Assigned to the Secretary of the Army:* This patent describes an impact fuze for blunt-nose bombs of the type which are normally dropped in clusters. The primer is resiliently mounted so that it will be forced against the firing pin by the force of inertia when the bomb strikes a hard target, and the firing pin is secured to a rupturable disk so that it will be separated from the disk and forced against the primer when the bomb strikes a soft target. Thus the fuze will function upon impact with either a hard material such as concrete or a material such as soft earth.

Fusible Link Jet Motor Control.—*U. S. Patent No. 2,749,705. Issued June 12, 1956, to Robert P. Haviland. Assigned to the General Electric Company:* This patent relates to multistage rockets or ramjets in which means are provided for accurately controlling the time of separation of the booster and succeeding stages. The desired control is accomplished by mounting in the path of the hot exit gases of the succeeding stage, or just downstream of its nozzle, an element which is almost instantaneously fusible under the heat of the gases, to interrupt the control circuit of the booster. Thus, as soon as the second stage is put into operation the first-stage operation is stopped, enabling the second stage to pull away cleanly.

Sonobuoy Dye Marker.—*U. S. Patent No. 2,750,027. Issued June 12, 1956, to Samuel N. Cummings:* This patent describes certain improvements in a device known as the Sonobuoy, which emits a dye upon being dropped into water. The dye is incorporated in such a manner that the buoy will give off a continuous stream of color from the moment it hits the water, regardless of whether it stands still, or drifts. The stream of color is of such volume and intensity as to leave a definite color trail or wake easily recognizable from the air.

Book REVIEWS

Reviews in this issue by:

COL. GEORGE S. BRADY, *consulting engineer, author, editor, Washington, D. C.*

F. W. FOSTER GLEASON, *military historian, ordnance analyst, editor, Washington, D. C.*

LIEUT. COL. S. M. SMOLENSKY, *engineer, Ordnance officer, Washington, D. C.*

BRIG. GEN. THOMAS K. VINCENT, *U.S.A. (Ret.), artillerist, engineer, author, Washington, D. C. (Died September 9, 1956)*

Designed for Digging. By Harold F. Williamson and Kenneth H. Myers, II. Evanston: Northwestern University Press. 384 pp. $7.50.

THIS is an unusual book in that it is the story of a single private corporation written by two members of an important university staff, and offered, not as business advertising but for sale on its own merits as an economic study of the inherent strength and capacity for growth of the American system of free enterprise.

The book is a part of Northwestern University's series of studies on business history. The choice of Bucyrus-Erie Company as the subject of the study of American manufacturing was apparently not by chance or by biased pressure, for it well meets the requirements of the university's intention to show how a typically successful capital-goods producer "adjusted its manufacturing, marketing, and financial policies to the various phases of the business cycle."

The various chapters recount the almost Horatio Alger growth of the company from the manufacture of mine cars in 1880 to the design and building of heavy steam shovels and excavators. Having been an engineer on the construction of the Panama Canal, this reviewer read with interest the chapter on this phase of the development. Bucyrus shovels were employed almost exclusively in digging the Canal, and it was the daring pioneer design of huge machines, never before contemplated, that made it possible to complete the Canal two years ahead of schedule and to open the way for the mechanization of open-pit mining and the rapid construction work later needed in World War I.

The chapters on progress in manufacturing techniques and industrial relations are also intensely interesting, and are typical of the progress that placed American manufacturing in the forefront in the world. The book is well recommended to any one interested in the study of American business.—GEORGE S. BRADY.

EDITOR'S NOTE.—*Readers of* ORDNANCE *will take special pride in this historic narrative because one of the founders of the Ordnance Association also is a founder of Bucyrus-Erie and the present chairman of its board. He is the distinguished Col. William W. Coleman, Lehigh University '95, who served as a special assistant to the Chief of Ordnance in the First World*

(Continued on p. 498)

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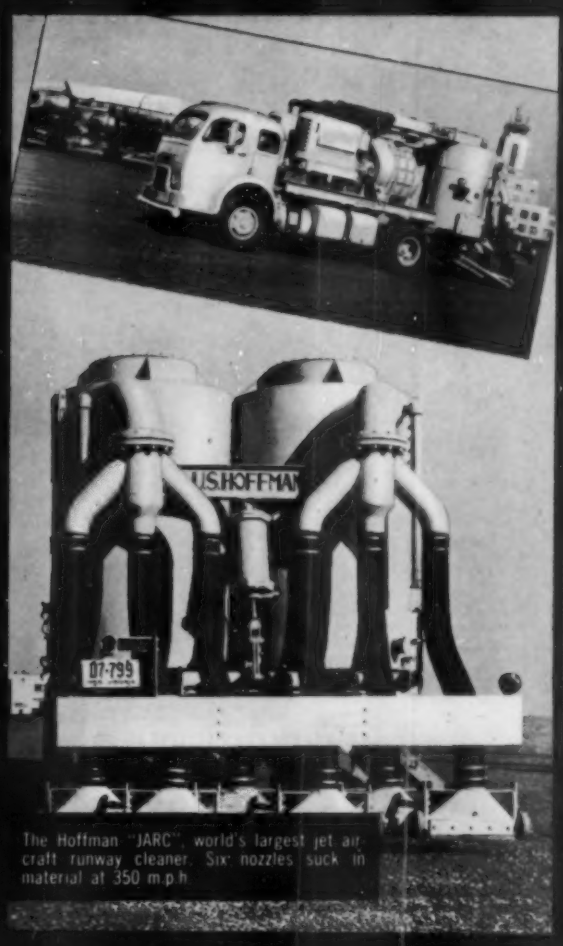

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Book Reviews (Contd.)

War. Colonel Coleman is a charter national director of the Association, having assisted in its formation in 1919. He can rightfully claim a major share of credit for at least two progressive institutions—Bucyrus-Erie and the Ordnance Association.

Small Arms and Ammunition in the United States Service. By Berkeley R. Lewis. Washington: Smithsonian Institution. 338 pp. $8.

MOST of America's military small arms, and some of the ammunition have been cataloged in various works, but here is a compilation of nearly all their details of tactical use and effectiveness, authoritatively given. It is backed by profuse documentation and bibliography. Hundreds of excellent drawings and photographs add visual clarity to the study. It is an ordnance enthusiast's delight.

The first of the seven chapters furnishes an always-needed résumé of general development of firearms and ammunition. Then come the items in meticulous yet well-chosen detail. Though the work will prove of consuming interest to any lover of historical arms, it is designed primarily as a tool for the serious student of military history and ordnance. As with any precision tool, the very great amount of detailed information makes for some initial difficulty in its use, but is far preferable to the frustration of missing details. Among the very many tables, perhaps the most noteworthy are the complete firing tests of differing types of weapons and ammunition which should be of especial interest to all students of small arms.

The book covers the period up to shortly after the American Civil War (the last table is dated 1878) which may cause disappointment to some readers. But the alternatives would be a skimping of valuable data or an unwieldy volume. Perhaps we can look forward to a companion work from the same competent hand.—F. W. FOSTER GLEASON.

Rocket Propulsion Elements. By George P. Sutton. New York: John Wiley & Sons, Inc. 483 pp. $10.25.

THE progress made in this fascinating field during the past ten years has been very rapid, although many of the details of this progress necessarily have been shrouded by military secrecy. In this text Mr. Sutton has done a remarkable job of presenting in one volume the fundamental and the practical aspects of the various phases of rocket propulsion. This book presents those basic elements, principles, and technical problems that are clearly understood in the present state of the art. A number of technical features are also presented to stimulate future investigations into the field.

This book is highly recommended as a reference to those engaged in the rocket-propulsion field and as an orientation for those about to enter the field.—S. M. SMOLENSKY.

Lincoln's Choice. By J. O. Buckridge. Harrisburg: The Stackpole Company. 254 pp. $5.

THE difficulties experienced by present-day arms inventors in obtaining acceptance of their brain children by the Ordnance Corps are not new. This book relates in interesting detail the difficulties experienced by Christopher Spencer in obtaining a chance to demonstrate his repeating rifle to the then Chief of Ordnance and the very positive turn-down which he received from that officer, after a rather cursory examination of the weapon. As the author put it, "Army Ordnance preferred muzzle-loaders. They were bigger than the breechloaders, cost less money, made more noise, and used fewer bullets per battle."

(*Continued on p. 500*)

Hunting—and the Man from Sleepy Hollow

"We descried a herd of buffalo about two miles distant, scattered apart and quietly grazing near a small strip of trees and bushes. Taking a wide circuit, we moved slowly and cautiously . . . then galloping along parallel, I singled out a buffalo and by a fortunate shot brought it down on the spot"—so wrote author Washington Irving of a hunting trip out West.

Yes, the hand that immortalized Rip Van Winkle and Ichabod Crane felt right at home around a rifle stock. Whenever Irving looked for relaxation, we're told he would take his gun and track the forests of Sleepy Hollow for fox, pheasant, duck or deer. Sometimes he made a kill—sometimes he didn't. But losing a quarry never spoiled his day. Hunting thrills and the healthy outdoors gave him a new outlook . . . brought him pleasure and sent him home refreshed.

Since pre-Revolutionary days, Americans have answered the call of hunting and the outdoor life. It's a sport that challenges wits, reflexes, stamina and skill. Equally important, hunting builds self-reliance and endurance, helping to keep our nation strong.

Today, the great American tradition of hunting can be perpetuated only by thoughtful preservation of wildlife. Throughout the country hunting associations are cooperating with public agencies to promote proper conservation. Do your part in preserving this heritage—join or support one of these groups now. E. I. du Pont de Nemours & Co. (Inc.), Explosives Department, Wilmington 98, Delaware.

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Small Arms and Ammunition in the United States Service

By Col. Berkeley R. Lewis

A study of the actual performance of America's early small arms by a well-known weapons historian and small-arms expert.

Here are the facts—interestingly written and supplemented with charts and pictures—on the effective range, accuracy, ammunition, and rate of fire of America's military small arms up to 1878. Ammunition, a subject largely neglected in earlier works, receives special emphasis.

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Book Reviews (Contd.)

Mr. Lincoln's order that all new ordnance should be submitted to him for his evaluation, together with the assistance of the Chief of Navy Ordnance, resulted in the direct order of the President requiring the procurement of a number of these Spencer rifles for the Union Army.

This book is a compact, hard-hitting, easy-to-read history of the five main Union campaigns and is an indictment of the Ordnance Department policies of those days—which happily have been relegated to that dim and distant past.—T. K. VINCENT.

Gray Fox—Robert E. Lee and the Civil War. By Burke Davis. New York: Rinehart & Company. 466 pp. $6.

THIS is an excellent personal study of the character of General Lee and of his peculiar army, whose men had little love for slavery or for the dominant class of slave owners and were held together only by devotion to their particular States.

The book leaves the question still open as to whether Lee was a fighter or a planner of strategy. But there is no doubt that his honesty of purpose and his high moral principles have won him a high place in American history. As the distance in years lengthens from the period of the Civil War, Lee will be more and more considered as a great American rather than as a great Confederate.

The many early victories of the Southern forces were individual successes and uncoördinated. Lee had been offered command of the Union Army by General Scott in 1861, and he might have had full command of the Confederates if he had demanded it. The author feels that it was the selfish desire of President Jefferson Davis to retain command, but the facts recounted in the book do not sustain this viewpoint. Davis may have been wise enough to see the difficulties of a unified command in a loose confederacy.

The early advantage of arms and supplies that had been attained by prewar transfers to Southern arsenals was soon gone. Without manufacturing facilities, arms had to be obtained by driving Union forces from the field and capturing supply trains. There was no leather or shoe manufacturing in the South, and fully one-third of the army was continually without shoes. Their greatest source of strength was in the incapacity and timidity of the Federal political generals.

The loss of Jackson prior to the Gettysburg campaign was a fatal blow to Lee's army, and Lee misjudged greatly the increasing resources of the new army he was to meet at Gettysburg. Lee had other spectacular fighters, but they were little stars in comparison with Jackson.

Longstreet's moral philosophy may not have been greater than that of Lee, but it appeared to be on a more organized basis. At Gettysburg, Longstreet believed it morally wrong to send Pickett on a hopeless charge. All that could be hoped from the charge was that Meade would be checked long enough to get the Confederate wagons of plunder safely across the Potomac River.

Lee understood the weakness of the Union generals whom he had known, and he was able to turn this knowledge into victories.

But by the summer of 1863 Lee was facing new officers whom he did not understand so well, and there were two new elements with which his ragged army could not cope—the new rapid-fire carbines and the endless new brigades of reckless Irish who were then pouring into the North as immigrants at a rate of 100,000 a year.

The author has produced such a good job in writing this volume that an only regret is that he did not go more deeply into source material. He might thus have made this study of General Lee a human classic.—GEORGE S. BRADY.

BOOKS RECEIVED

Cryptanalysis—a Study of Ciphers and Their Solution. By Helen Fouche Gaines. New York: Dover Publications, Inc. 237 pp. $3.95.

Dictionary of Poisons. By Ibert and Eleanor Mellan. New York: Philosophical Library. 150 pp. $4.75.

Dodge Engineering Catalog. Published by Dodge Manufacturing Corporation, Mishawaka, Ind. 328 pp. NP.

Electronics. By A. W. Keen. New York: Philosophical Library. 256 pp. $7.50.

Elevated-Temperature Properties of Coppers and Copper-Base Alloys. Prepared by Clair Upthegrove and Henry L. Burghoff. Philadelphia: American Society for Testing Materials. ASTM Special Technical Publication No. 181. 248 pp. $5.50.

International Dictionary of Physics and Electronics. New York: D. Van Nostrand Company. 1,004 pp. $20.

Machinists' Ready Reference. Compiled by C. Weingartner. Ann Arbor: Prakken Publications. 139 pp. $1.50.

Moscow and the Communist Party of India. By John H. Kautsky. New York: John Wiley & Sons, Inc., and the Technology Press of the Massachusetts Institute of Technology. 220 pp. $6.

Proceedings, 1956 Electronic Components Symposium. New York: Engineering Publishers. 240 pp. $8.25.

Symposium on Impact Testing. ASTM Special Technical Publication No. 176. Philadelphia: American Society for Testing Materials. 169 pp. $3.50.

An 80% machining advantage...as well as superior mechanical properties are obtained by the switch to ductile iron castings for this turret lathe and other machine tools produced by The Warner & Swasey Company, 5701 Carnegie Avenue, Cleveland 3, Ohio. Shown above are typical parts now cast in ductile iron to cut both production and maintenance costs. Combining the best features of cast iron and steel, ductile iron is easy to cast and machine, yet provides high strength and toughness.

Warner & Swasey improves 275 turret lathe parts with ductile iron

Clutch plates, hinges, levers, tool holders, wrenches . . . 275 parts in all . . . are now specified in ductile iron for Warner & Swasey turret lathes.

MONEY-SAVING MACHINABILITY

was one reason for Warner & Swasey's adoption of ductile iron. The machine shop reports an 80% advantage in machining operations for ductile iron castings over the malleable iron parts they replaced. The ductile iron castings cut readily and evenly at hardness levels of 170-190 BHN. This means worthwhile savings in machining costs, but there are other advantages, too.

HIGH MECHANICAL PROPERTIES

Ductile iron castings provide a combination of strength, hardness and toughness that makes them dependable for severe use in machine tools. Specifying ductile iron type 60-45-10, Warner & Swasey finds the castings provide an average yield strength of 56,250 psi and elongation of 16%. These parts also have a high level of wear resistance.

AND CASTABILITY

The good fluidity of ductile iron permits filling intricate molds . . . improving quality of the castings and quantity of output regardless of wide variations in section thickness.

You, too, can cut machining costs and improve your products or equipment by using ductile iron castings. Get all the facts in "DUCTILE IRON, The Cast Iron THAT CAN BE BENT." Write for your copy now.

ductile iron . . . the cast iron that can be twisted and bent

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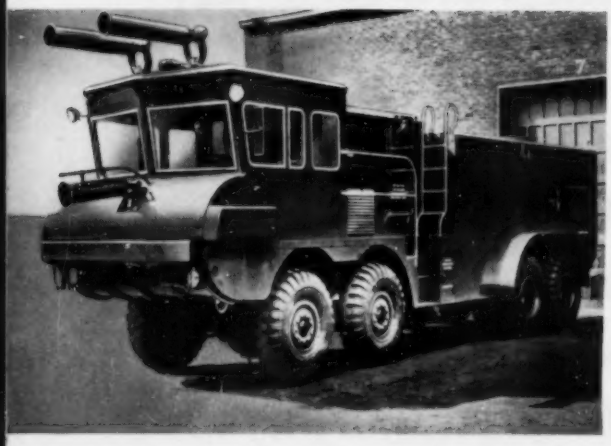
67 Wall Street, New York 5, N. Y.

When the terrain is roughest and the going toughest...

THE VERSATILE "8x8"

CHALLENGE



U.S. Air Force experimental crash truck

U.S. Army experimental troop and cargo carrier

The "8x8" gives you a better combination of ALL-WHEEL TRACTION LOAD DISTRIBUTION • WHEEL FLOATATION than any other heavy-duty vehicle available today!

Under the most difficult test conditions the "8x8" is proving its greater versatility—ruggedness—and dependability in every way.

These amazing experimental military vehicles provide dependable full-time, all-wheel traction . . . low floatation pressure at each wheel . . proven cargo stability and ride . . . better controllability . . . and greater load capacity in relationship to vehicle weight.

And another big *plus* in the TDA® driving assemblies on these vehicles is the interchangeability of component parts. They are standard military production items that can be assembled in a variety of ways – to make driving units for four, six or eight wheel vehicles.

Timken-Detroit® pioneered the development of multi-wheel drives. Today, in cooperation with prime contractors and the U. S. Department of Defense, TDA continues to develop and improve multi-wheel drives for new uses – greater adaptability.

If you have a problem in power transmission – consult Timken-Detroit Axle. Fifty years of manufacturing experience – and continuing field and laboratory research – will help you find the answer quicker, easier – and at less cost in the long run.

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MILITARY VEHICLES

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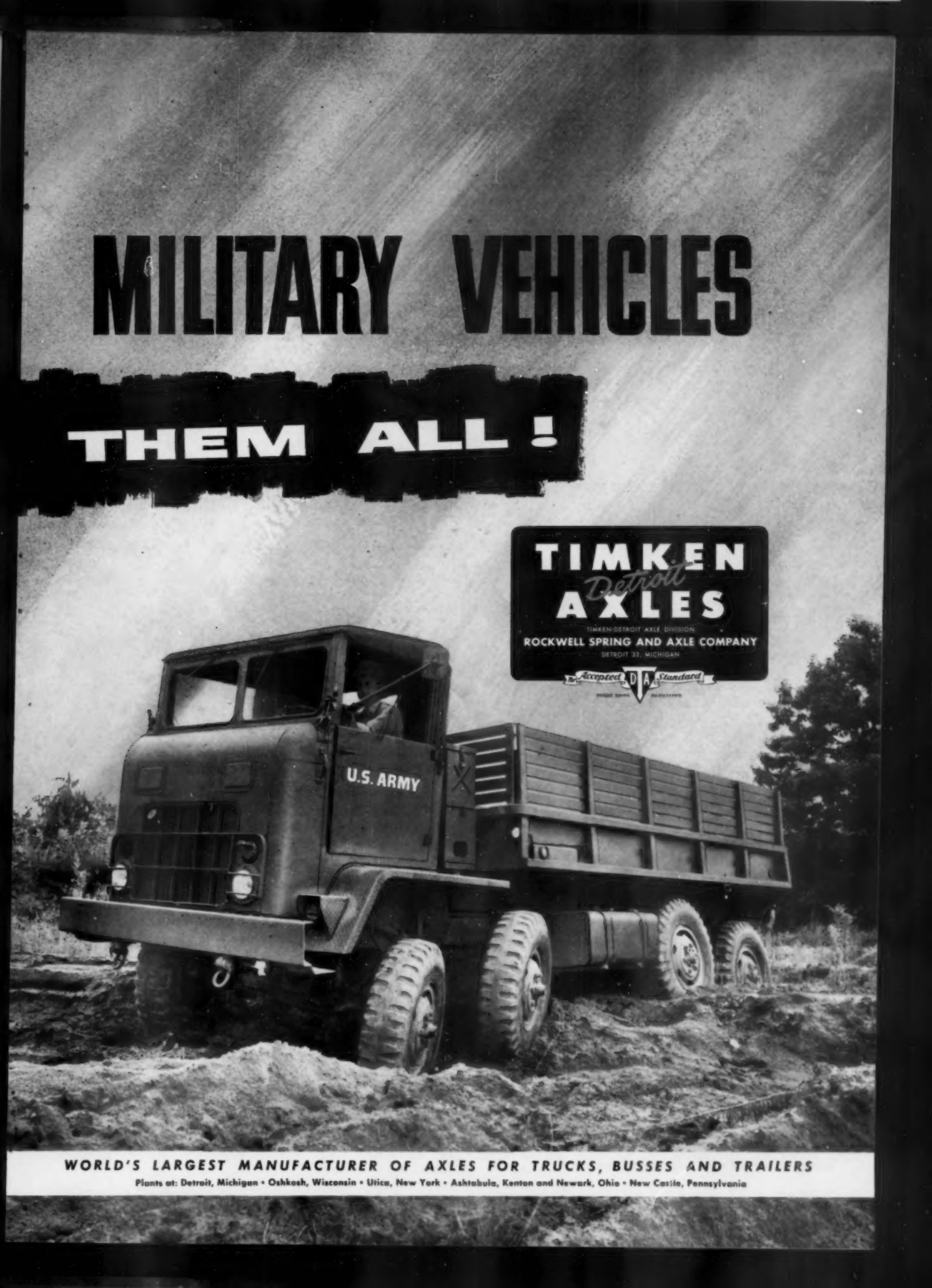
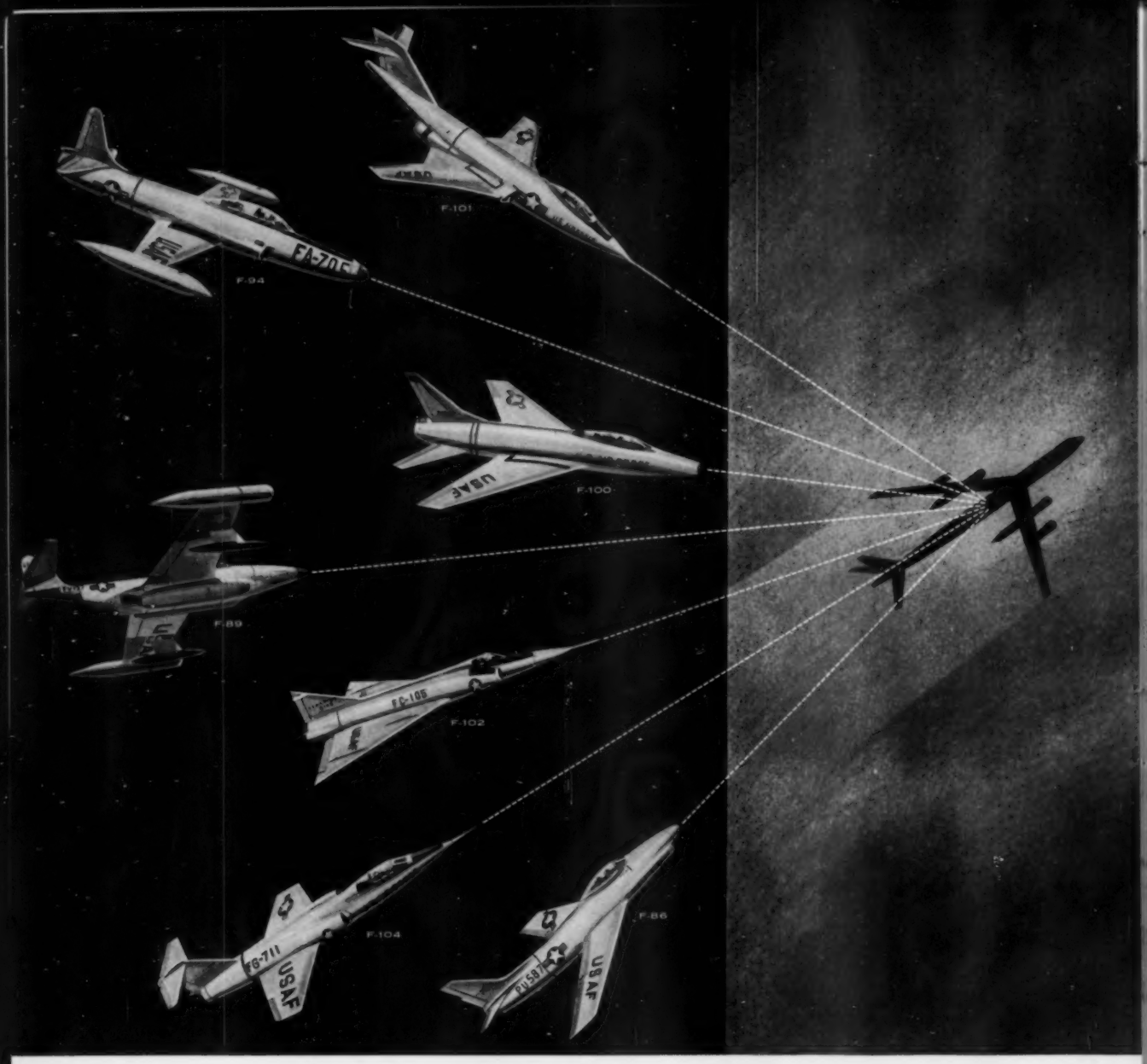


WORLD'S LARGEST MANUFACTURER OF AXLES FOR TRUCKS, BUSSES AND TRAILERS
Plants at: Detroit, Michigan • Oshkosh, Wisconsin • Utica, New York • Ashtabula, Kenton and Newark, Ohio • New Castle, Pennsylvania



Fire control radar tells... / WHERE TO AIM WHEN TO FIRE!

All-seeing radar pinpoints the target for these Air Force planes. Whatever armament they carry—guns, rockets or missiles—fire control radar tells them *where* and *when*. It provides the far-sighted vision necessary for modern long-range combat operations.

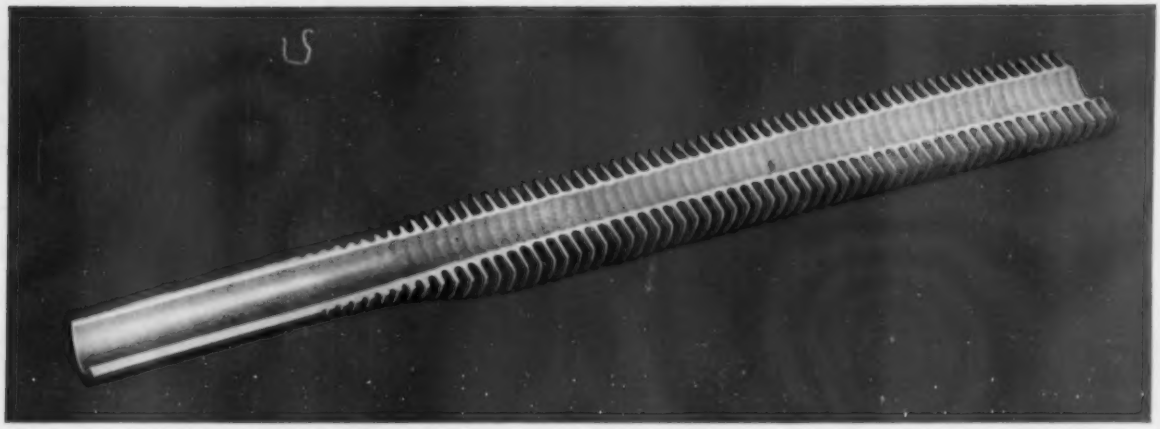
Today's modern fighter plane is an electronic wonder, with fire control radar-computer systems supplying a continuous flow of information about target position in terms of range and rate of closing.

RCA is a major supplier of airborne fire control equipment to the Armed Forces. Its activity in developing and producing these systems requires a close working relationship with the airframe industry and the Department of Defense, a "partnership" vital to the success of any weapons system.

Defense Electronic Products

RADIO CORPORATION of AMERICA

Camden, N.J.



WOLVERINE TRUFIN® The Integral Finned Tube

Wolverine Trufin —Big Step Forward in Heat Transfer

Probably the most significant advance in heat transfer applications came with Wolverine Tube's development of Wolverine Trufin—the integral finned condenser tube.

Trufin is an extended surface tube with fins squeezed directly from the tube wall. Because of this it has more than twice the heat transfer surface of plain tube—extracts more BTU's per foot of tube.

Wolverine Trufin is available in aluminum as well as in copper, copper-base alloys and electric-welded steel. Because its fins are actually part of the tube wall they are unaffected by vibration, temperature changes or pressure variations.

Trufin is available in five distinct types with fins varying in height and number per inch. High finned aluminum Trufin is particularly effective in air-cooled heat transfer applications.

FREE CATALOG BIG HELP TO MANUFACTURERS

A complete description of Wolverine Tube's product line and fabrication facilities is contained in the General Products Catalog. Your request will start it on its way to you without any obligation. Write today!

New Trends Noted:

ALUMINUM TAKES NEW FORM IN WOLVERINE FABRICATION

Today, wherever aluminum is used in the metalworking industry, a new trend is becoming increasingly apparent.

By using the fabrication facilities of supplier firms like Wolverine Tube, many aluminum manufacturers are reducing their production operations and releasing manpower, floor space and equipment for other duties. The net result is a definite saving in time and money plus a real boost in efficiency.

A prime example of Wolverine's fabrication ability is found in its refrigeration evaporator sub-assembly which is proving a real time-saver to busy refrigeration manufacturers. This prefabricated assembly is composed of a bunch-type aluminum coil, a one-piece accumulator (produced in one operation by Wolverine's exclusive Aluminum Spun End Process®) and two copper-to-aluminum connectors.

OTHER WOLVERINE ALUMINUM PRODUCTS

Famed for its Tubemanship, Wolverine Tube produces aluminum tube in a wide range of sizes and alloys in both drawn and extruded form. This rigidly quality controlled product is available in straight lengths, medium length coils and extra long coils.

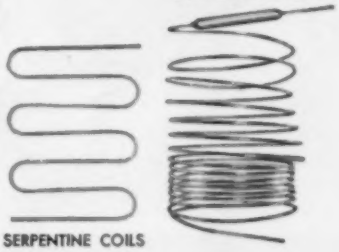
Still another of Wolverine's varied operations is the production of extruded aluminum shapes to customer specifications.

STRAIGHT LENGTHS

Also important is Wolverine's production of aluminum serpentine coils which give a maximum length of tube in small space. Other Wolverine fabrication facilities include finning, coiling, bending, flaring and expanding—to name but a few.

PROCESS PATENT APPLIED FOR

EVAPORATOR COIL



SERPENTINE COILS

DIVISIONS OF CALUMET & HECLA, INC.

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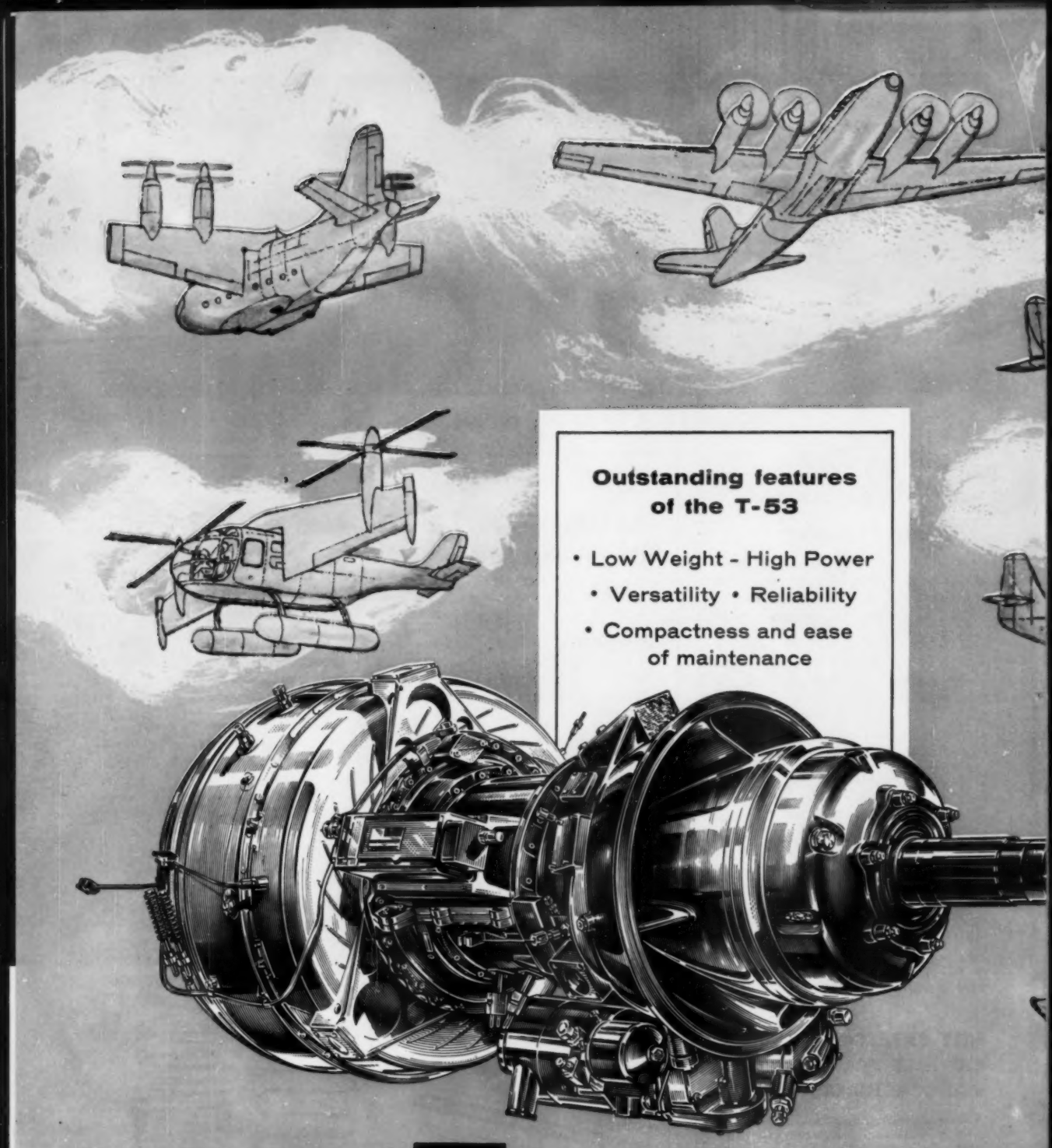
WOLVERINE TUBE

Division of Calumet & Hecla, Inc.
1449 Central Avenue, Detroit 9, Mich.
Manufacturers of Quality Controlled Tubing and Extruded Aluminum Shapes

Wolverine Trufin is available in Canada through the Unifin Tube Co., London, Ontario

PLANTS IN DETROIT, MICHIGAN, AND DECATUR, ALABAMA. SALES OFFICES IN PRINCIPAL CITIES.

EXPORT DEPT., 13 E. 40TH ST., NEW YORK 16, N. Y.



Outstanding features of the T-53

- Low Weight - High Power
- Versatility • Reliability
- Compactness and ease of maintenance

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defense and industrial products

When you take gas turbines out
of the lab and put them into the air...

The New
LYCOMING T-53

weighs 75 pounds less
than any other complete engine
of comparable h.p.
for turbo-prop applications!

For the rapidly expanding field of STOL and VTOL aircraft, the new Lycoming T-53 offers a more challenging potential than any turboshaft engine ever developed in the "small-power package" range.

Developed under the sponsorship of the U. S. Army and the U. S. Air Force, the T-53 has already been selected to power the Army's newest Utility 'Copter (Bell XH40). Bell and Kaman have received their flight test engines. Even now the T-53 is being installed in boats, and stationary power plants are under consideration. Yet it is in the field of turbo-prop applications that the T-53 might very well offer its most exciting possibilities.

Ready to take to the air, the complete turbo-prop weighs only 460 lbs. and delivers 960 h.p. from a compact 47.6 length x 23-in. diameter. Using a variety of fuels including automotive and aviation types, gasoline and JP-4, it operates at a low 0.655 lbs. per e.s.h.p. per hr. consumption. Rugged design features and unprecedented ease of maintenance guarantee safe operation and long life.

In addition to its weight advantage as a turbo-prop, the Lycoming T-53 could be made available with front-end or rear-end power take-off or simultaneous power extraction at both ends.

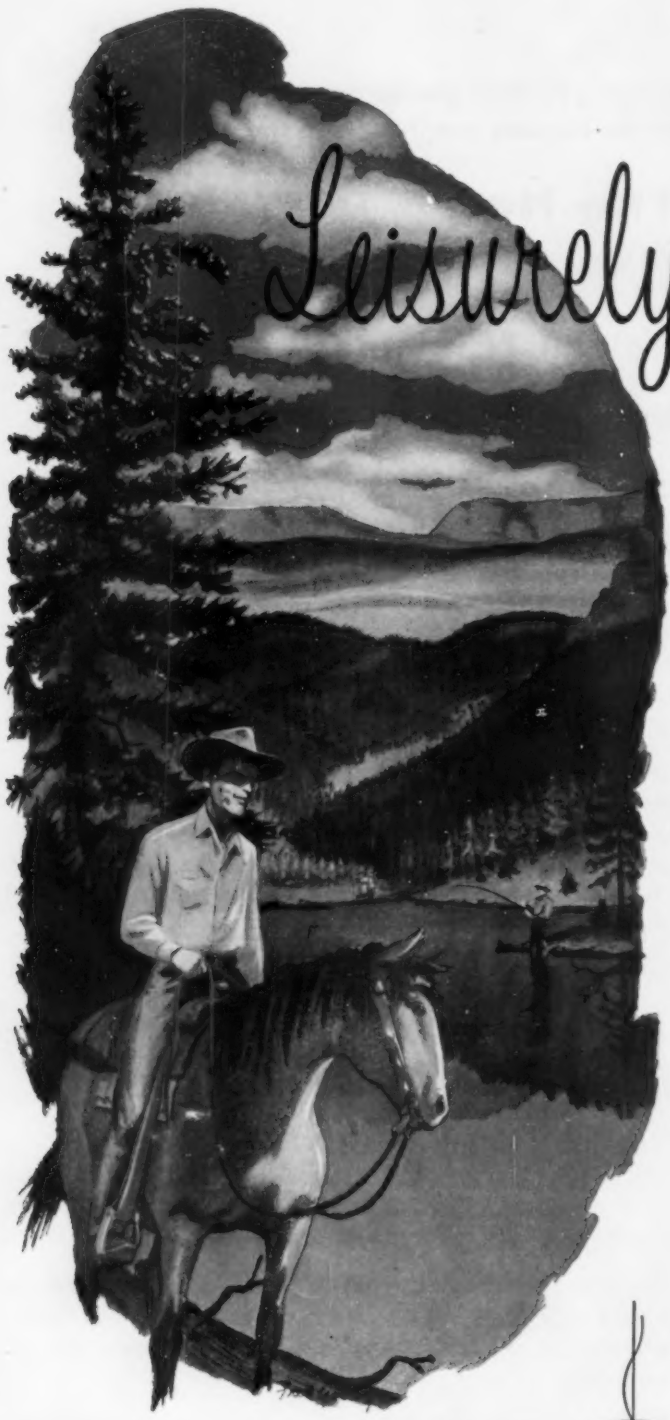
There can be no doubt that the T-53 will set new standards for small aircraft. Developed by the men who built the first mass-produced jet engine to fly, Lycoming's T-53 may solve the turbo-prop problems you're facing *right now!*

To learn more about the T-53 and Lycoming's ample facilities to produce it, phone, wire or write for turbine information to Avco Lycoming, Stratford, Conn.

ENGINEERS WANTED

Challenging opportunities for outstanding men in the gas turbine field. Write Vice President, Industrial Relations, Stratford, Conn.

TODAY'S MILITARY SERVICES, WITH THEIR TREMENDOUS TECHNOLOGICAL ADVANCES MADE POSSIBLE THROUGH SCIENCE, OFFER A VITAL REWARDING CAREER.



Los Alamos Scientific Laboratory is located in a delightful small city, high in the pine forests of northern New Mexico. It is a city of

Leisurely living...

and Career Opportunities in Engineering

The Laboratory has immediate openings for:

MECHANICAL ENGINEERS

Challenging problems in the design of weapon components, their fabrication and testing; design, control, and testing of reactors; support of programs in nuclear physics research including an intriguing variety of work in controls, machine design, gaging.

CHEMICAL ENGINEERS

Development and research in formulation and fabrication of new materials; design and preliminary manufacture of weapon components for systems testing; studies in fluid flow and heat transfer, particularly in systems at high temperatures and pressures, recovery and purification of radioactive materials by remote control processes.

ELECTRICAL AND ELECTRONICS ENGINEERS

Creative development of instrumentation for recording the history of events which occur in times as short as milli-microseconds; a wide variety of instrumentation including scintillation counters, fast pulse amplifiers, fast oscilloscopes.

CHEMISTRY AND METALLURGY

Work in these fields includes high temperature thermodynamics, properties of rare metals, development of high temperature fuels and structural materials for nuclear reactors, radiochemistry, radiation chemistry, uranium and plutonium metallurgy and chemistry, complex ion chemistry, microanalysis, isotopic analysis.

If you feel you are an above-average candidate, if you want to join the scientists at Los Alamos working at the very frontiers of their field, write:

Director of Scientific Personnel
Division 1418

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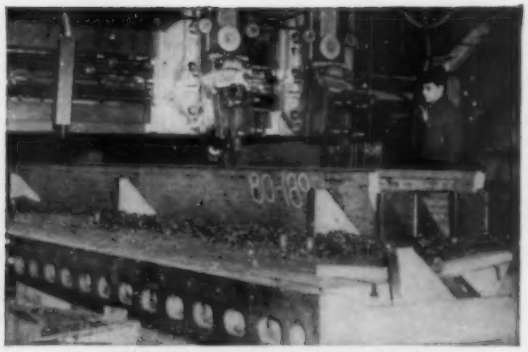
Los Alamos Scientific Laboratory is operated by the University of California for the U. S. Atomic Energy Commission.

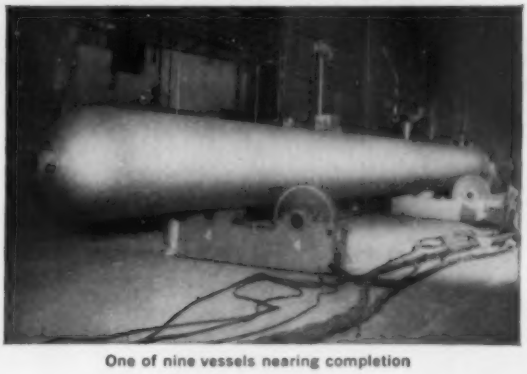
FOSTER WHEELER FABRICATES "T-1" STEEL

Bending 2 in. "T-1" steel plate on 8000-ton beam press



Machining mating surfaces of half shell

Automatic welding of exterior seam



One of nine vessels nearing completion

THE FORMING and welding of high-yield-strength "T-1" steel has been extensively investigated by Foster Wheeler and a number of pressure vessels have now been successfully fabricated of this new material. Operations in the manufacture of one of these vessels are shown above.

The 8000-ton beam press at Foster Wheeler's Mountaintop, Pa., plant was used to form the flat "T-1" steel plate, 2 in. thick, into half shells which were machined and welded into a full cylinder. Bending techniques were developed and conservative limits established to control maximum bending stresses. The toughness of the steel was unaffected by cold bending within these established limits.

After exploring several welding processes, the automatic submerged melt technique was found most satisfactory, meeting the required joint efficiency of 100 percent in the stress relieved condition.

For end closures, where inside back welding could not be used, a procedure was developed for 100 percent penetration welding without backing strips.

Foster Wheeler's specialized experience and extensive shop facilities are available for the heavy fabrication of "T-1" steel or other high-yield strength steels. For further information, write to *Foster Wheeler Corporation, 165 Broadway, New York 6, N.Y.*

FOSTER WHEELER

NEW YORK • LONDON • PARIS • ST. CATHARINES, ONT.

Two of America's Most Modern

22 BLISS HYDRO-DYNAMIC PRESSES WORK FOR BOTH ARMY AND NAVY AT EKCO PRODUCTS

At Ekco Products Company, Chicago, one line of Bliss presses ranging from 75 to 2500 tons produces 76 mm cartridge cases... and another line of eleven makes 3"/50 Navy cases.

The speed at which the lines are operated is "classified" information, but you may be sure it is exceptionally fast. As a matter of fact, their performance so exceeded their original "specs" that the lines have become known throughout the ordnance world.

Press operations on both lines are the same—a series of eleven steps beginning with pre-cupping a steel blank, then cup, four draws, pre-head, final draw, heading, and two tapering operations. Only difference between the Army and the Navy lines is a slight variance in tapering techniques.

Designing and building entire ordnance lines, both hydraulic and mechanical, has been a specialty of Bliss since Spanish-American War days. Today, Bliss press lines are as common throughout ordnance as they are throughout industry at large.

If you have a pressed metal problem, put this experience to work—let Bliss help you pick the one right press—or press line—for the job.

PRE-CUPPING—Army and Navy case production on each line begins with a Bliss 250-ton single-action Hydro-Dynamic press. First operation on press at right is pre-cupping flat disk blank. Blanks move from there into a second 250-ton press for cupping.

DRAWING—Third draw is made on this Bliss 125-ton press. Long punch stretches case to almost its final length. (Two more draws complete the job.) Long strokes combined with fast approach and return speeds suit this press to production of steel cases.

BLISS
SINCE 1857

is more than a name... it's a guarantee

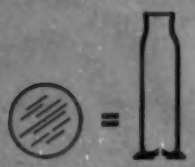
E. W. BLISS COMPANY, Canton, Ohio
Presses, Rolling Mills, Rolls, Special Machinery

Steel Cartridge Case Lines

HYDRO BLISS DYNAMIC

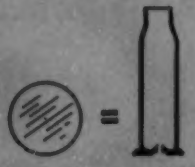
Eleven Press Operations On Each Line

ARMY



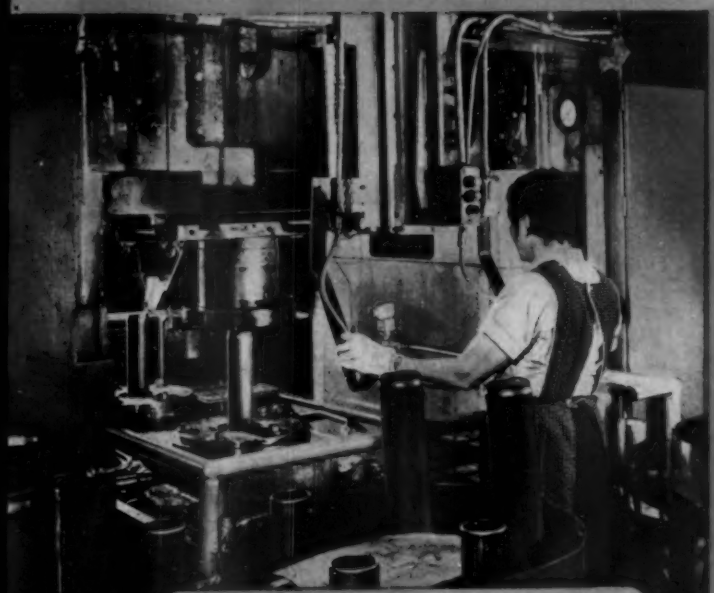
From this...to this

NAVY

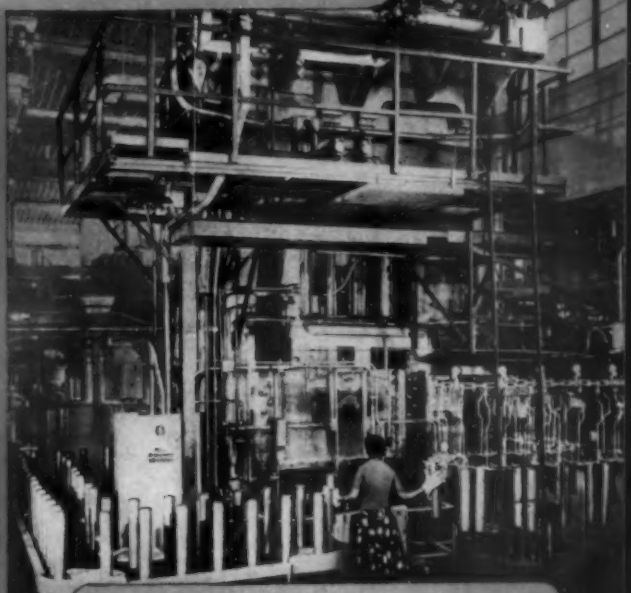


From this...to this

OPERATION	PRESS	CAPACITY
1. Pre-Cup	Bliss HS250	250
2. Cup	Bliss HS250	250
3. First Draw	Bliss HS200	200
4. Second Draw	Bliss HS150	150
5. Third Draw	Bliss HS125	125
6. Fourth Draw	Bliss HS100	100
7. Pre-Head	Bliss HS1500	1500
8. Fifth Draw	Bliss HS75	75
9. Head	Bliss HS2500	2500
10. First Taper	Bliss HS75	75
11. Second Taper	Bliss HS75	75



PRE-HEADING—This 1500-ton press, which pre-heads cases, is equipped with a Bliss-designed shuttle, allowing it to be loaded with one case while another is still in the press. Shuttle makes it easier to load and unload thus speeding production.



HEADING—Heaviest press in each line is a Bliss 2500-ton heading press. Large pumps on top provide smooth flow of high pressure oil to the slide. Pumps are simple and rugged, with peak rating well above maximum press tonnage.

U. S. Plants: Canton, Cleveland, Salem and Toledo, Ohio; Detroit and Hastings, Michigan; San Jose, California, Midland and Pittsburgh, Pa.
Branch Offices: Boston, Burbank, Chicago, Cleveland, Dayton, Detroit, Indianapolis, New Haven, New York, Pittsburgh, Philadelphia, Rochester, Salem, San Jose, Toledo, Washington, D.C. and Toronto, Canada; E. W. Bliss (England) Ltd., Derby, E. W. Bliss Co., (Paris), France.
Other representatives throughout the world.

DOW

Dow high temperature magnesium alloys have excellent fabrication characteristics

Lightweight structural metals with high strength, stiffness and elasticity at elevated temperatures! A new group of Dow magnesium alloys offers a great combination of these properties without the fabricating difficulties normally experienced with other high temperature materials.

Specially developed for use in airframes, missile and engine structures, the new alloys are already making weight reductions possible for several manufacturers. These alloys show advantages at temperatures up to 700°F. Limited test data on properties up to 800°F. are available for some of them.

FABRICATION: Fabrication characteristics are equal to those of standard magnesium alloys.

WELDABILITY: 95 to 100% weld efficiency at elevated temperatures.

FORMABILITY: Single deep draws can be easily accomplished.

MACHINABILITY: Best machining characteristics of any structural metal.

One of the new alloys is magnesium-thorium composition HK31A. It is now available in rolled form from stock. Castings and sheet in mill quantities are also readily available. A companion alloy for extruded shapes and forgings will soon be in production.

For more information about the new high temperature magnesium alloys, contact your nearest Dow Sales Office or write to THE DOW CHEMICAL COMPANY, Magnesium Sales Department MA 362H, Midland, Michigan.

EASILY FORMED. These HK31A parts were drawn using production dies and processes for standard magnesium alloys. The parts retained a higher percentage of original properties than standard alloys.

you can depend on DOW MAGNESIUM DOW

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for packing and handling, industrial and military products

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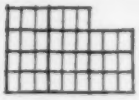
STACK BETTER  **STORE BETTER**

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IN ANY KIND OF WEATHER **NOTHING**

TOO BIG **...NOTHING TOO HEAVY**

NOTHING

TOO DIFFICULT, ALL AT A LOWER TOTAL COST!

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WIREBOUND BOX MANUFACTURERS ASSOCIATION
327 South LaSalle Street, Room 1163, Chicago 4, Illinois

Radiation effects being studied in special laboratory

The flight date of the first atom-powered airplane may well be advanced as the result of a study being conducted by Admiral for the U.S. Air Force. The problem is to determine the effects of nuclear radiation on electronic components.

All types of electronic components . . . such as tubes, resistors, condensers, capacitors and coils . . . are first bombarded by neutrons to make them radioactive prior to observation and testing.

Admiral has equipped a special nucleonics laboratory to make this study. Test equipment is set up within heavily shielded "hot cells" and operated by remote controls outside each room. One of the "hot cells" contains environmental chambers for testing the radioactive components under extreme temperature and altitude conditions. The laboratory also contains shielded underground storage facilities and a cobalt 60 source of gamma radiation as powerful as some atomic reactors.

Working with radioactive materials is not new to Admiral. For the past seven years the company has been engaged in designing, manufacturing and testing radiation measurement equipment. In this connection Admiral engineers have contributed much to the combined nucleonic-electronic sciences.

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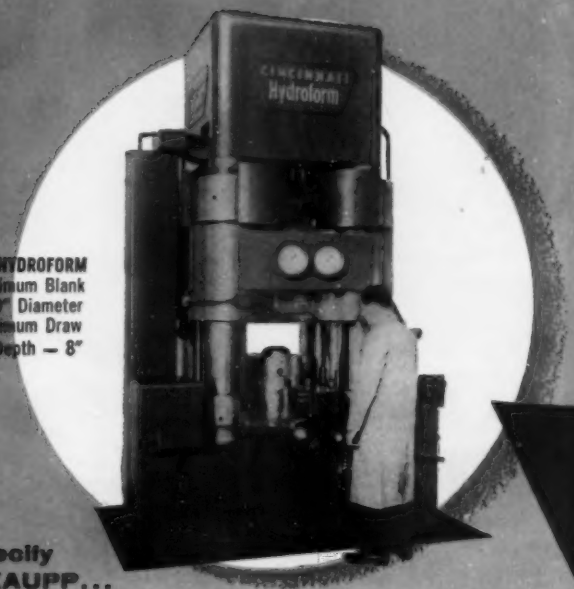

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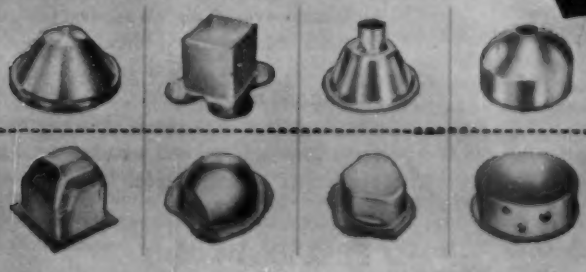

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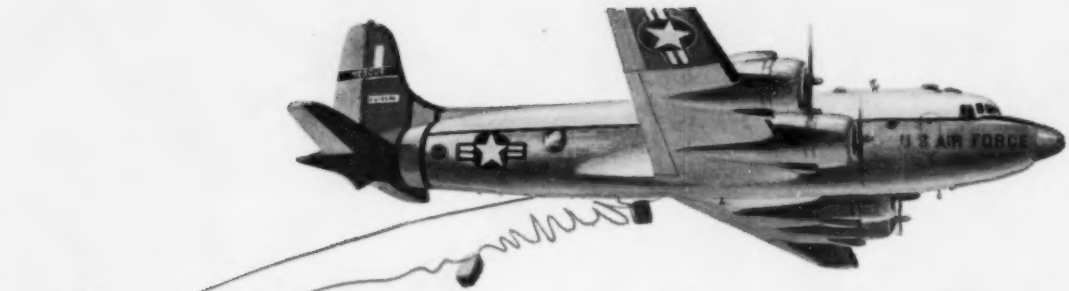

This bombardier calls a near-miss perfect

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Greater speed and economy make the C-54 Skymaster ideal for both actual rescues *and* the long patrol missions Air Rescue Service flies. Increased fuel capacity keeps C-54 aloft for 18 hours or more. *One* plane can drop 4 new-type raft rescue kits with a life-saving potential of 160 people.

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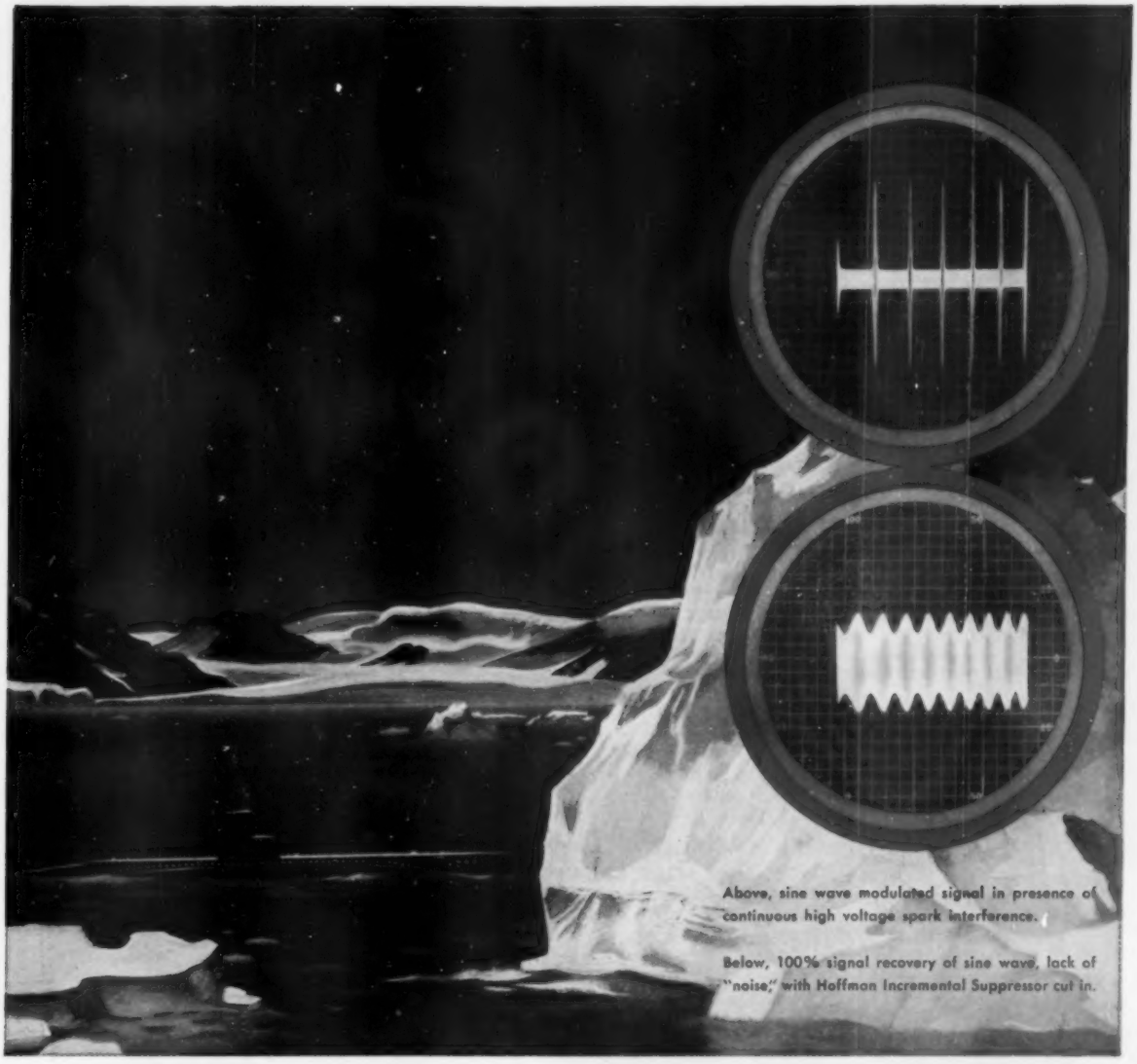

Above, sine wave modulated signal in presence of continuous high voltage spark interference.

Below, 100% signal recovery of sine wave, lack of "noise," with Hoffman Incremental Suppressor cut in.

HOW TO GIVE NOISE THE SILENT TREATMENT

SITUATION: *A submarine surfaced somewhere in iceberg country, attempting to establish communications with distant base.*

PROBLEM: *Interference, or "noise," critically garbles message reception. Radio operator cannot hear message above interference.*

SOLUTION: *Operator switches on Hoffman Incremental Interference Suppressor, an exclusive feature of Hoffman Communications Receivers. Atmospheric noise is silenced—vital message comes through loud and clear.*

This significant achievement in the science of communications has undergone extensive field tests under rugged service conditions. Tests demonstrate that in CW, FSK and AM communications, Hoffman-developed noise limiting techniques can give 100% message recovery from a signal containing atmospheric static 80 decibels greater than the carrier. Interference caused by static, corona discharge, lightning and most man-made noise is reduced to a minimum. Result: clear, reliable radio-communications under extremely adverse operating conditions. The imaginative engineering teamwork and skill that pioneered in the reduction of noise in radio communications is ready to tackle your communications problems too—from basic research through final production.

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An important factor contributing toward making the Forrestal "the most powerful ship ever built" is the dependably accurate Automatic Gun Fire Control system which guides the fire of its anti-aircraft guns. Designed and built by the Reeves Instrument Corporation in conjunction with the U. S. Navy Bureau of Ordnance, this equipment, service tested on the USS FORRESTAL, has since been installed on its sister ship, the USS SARATOGA.

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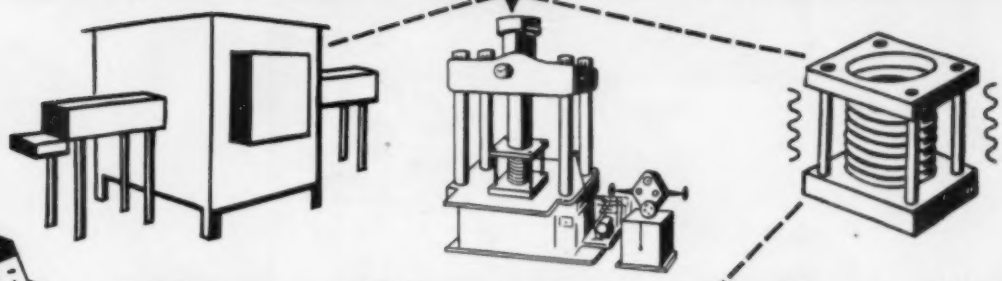

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THE PROBLEM — Industry and Government are engaged today in a gigantic effort to develop new alloys and stronger metals. The future security of America depends on the success of this program. Powder metallurgy, possessing unique advantages not common with any other process, can solve many of the tough metallurgical problems created by the jet age.

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THE ANSWER — Metal Carbides has found that by combining the best features of the above processes — with the right combination of metals and materials — totally new advantages result. Whether you require a structure that is porous, dense or tough — or a material that will withstand heat, corrosion or shock — let us put our experience to work helping you reach your objective! **Metal Carbides Corporation, Youngstown 7, Ohio.**

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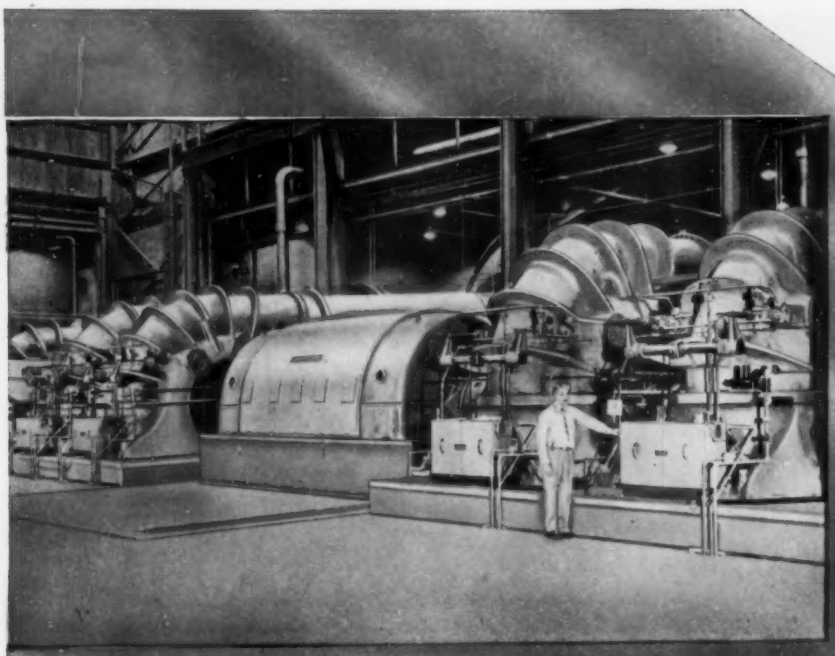
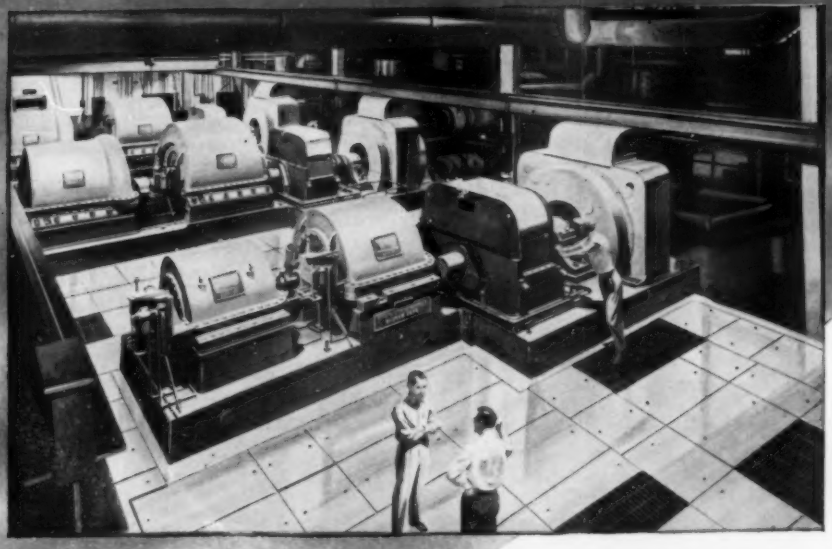


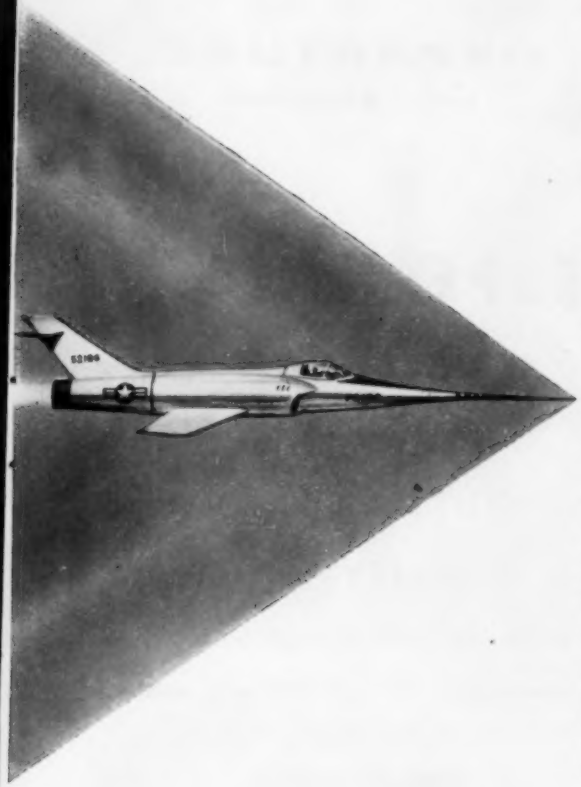
Five R-C single-stage centrifugal blowers developing over 1,000,000 cfm direct driven from electric motors rated at more than 80,000 HP at Langley Field, Virginia.

Six R-C multi-stage blowers rated over 75,000 cfm requiring about 14,000 HP, part of a centrifugal installation at Lewis Flight Propulsion Laboratory in Cleveland.



Roots-Connersville creates

STOP-AND-GO WHIRLWINDS FOR AIRCRAFT RESEARCH



Man-made air masses that match the violence of nature's hurricanes pour from the Roots-Connersville Blowers at the Lewis Flight Propulsion Laboratory of the National Advisory Committee for Aeronautics. Yet the power of these huge wind-making machines can be instantly controlled, from a soft, whispering breeze to a roaring, whirling cyclone. In the reverse, the siphoning air movement can develop almost perfect vacuums to simulate the air conditions of high altitudes. A similar but larger N.A.C.A. "wind-making system" is now being completed at Langley Field, Virginia.

The same engineering and manufacturing abilities that developed these stop-and-go whirlwinds are applied by Roots-Connersville to the everyday movement of gas and air, in small or large quantities, for industry. Now in its second century of service, Roots-Connersville Blower Division, one of the Dresser Industries, builds the world's most extensive and varied line of such equipment.

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General Mills scientists are finding some of the answers to this question, which bears directly on space ships and man-made satellites.

Their findings indicate that materials to be sent into space must possess properties not found in today's ores and alloys. Since few new metals remain to be discovered, they conclude that present ones must be given new properties to cope with the heat barrier and to keep vehicles from disintegrating under particle bombardment.

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Findings in this "research for tomorrow" are being translated regularly into practical applications for industrial and military use today. If you have product or production problems, you can profit from these applications, and from our high-level production facilities.

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From General Mills' creative research and precision manufacturing come machines for industry to use today—machines such as *Autofab*, for near-automatic assembly of electronic components on printed circuit boards.

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Find out how the FRINGECOUNT can be used in your operation; Write us today, Department..... for Bulletin LP-3521.

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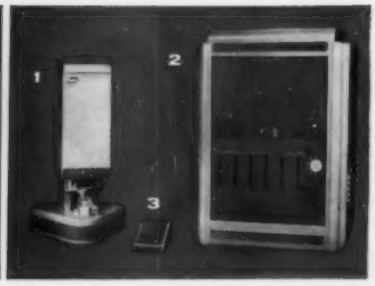
3 **CONTROL UNIT** . . . push button controls provide bi-directional operation of the motor driven head and zero setting of the instrument.



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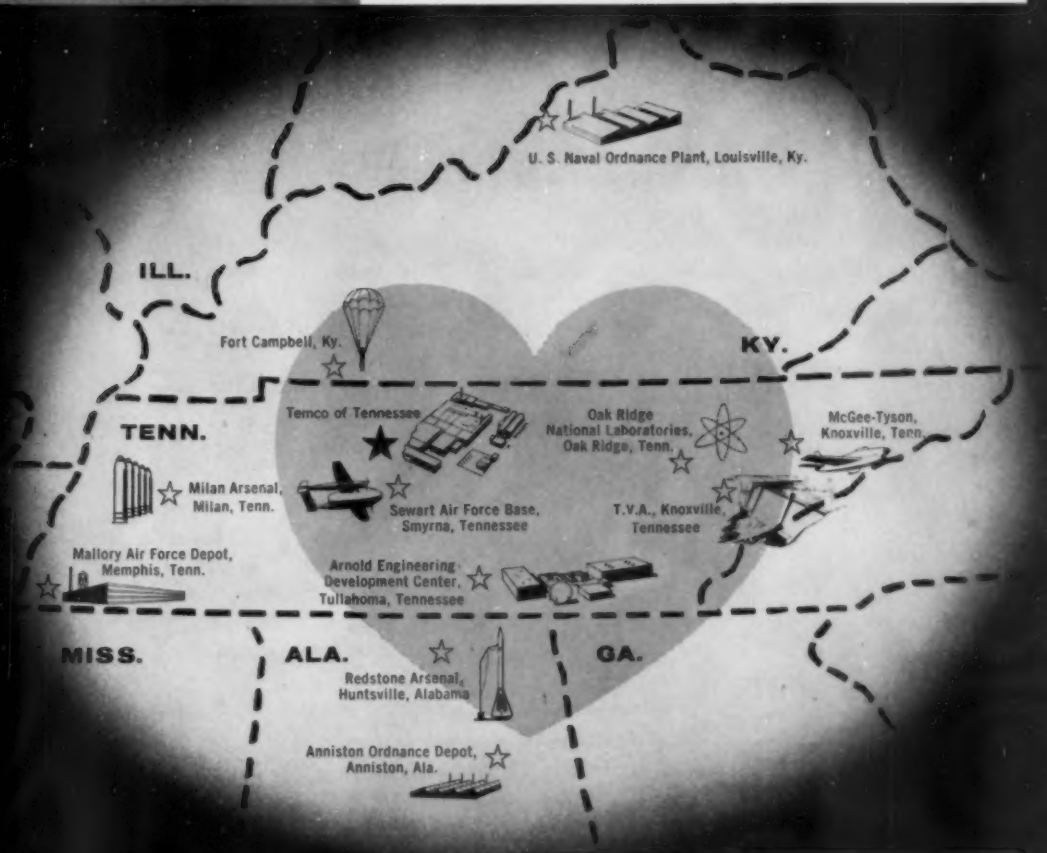

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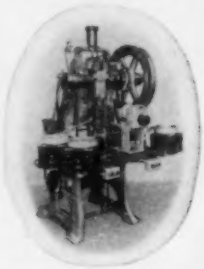

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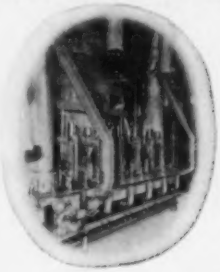

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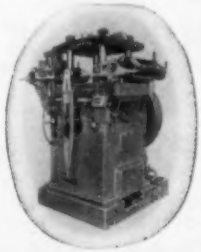

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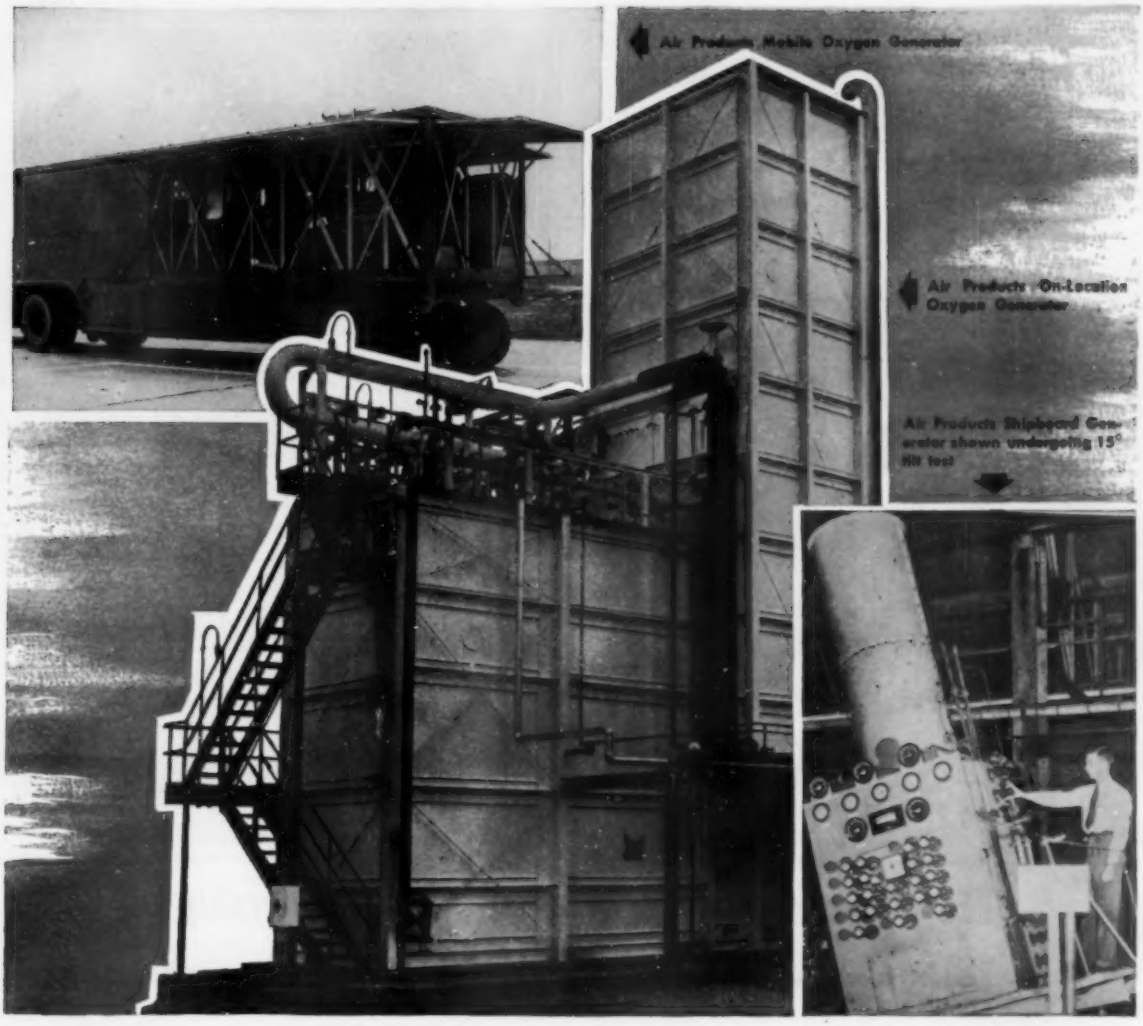
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708 Mills Building, Washington 6, D. C.

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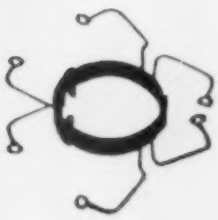
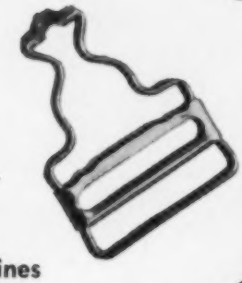


Wire forms



Complete manufacturing facilities—all under one roof. Our automatic four-slide machines and presses can deliver precision-made parts in an extensive variety of ferrous and non-ferrous metals.

Metal stampings

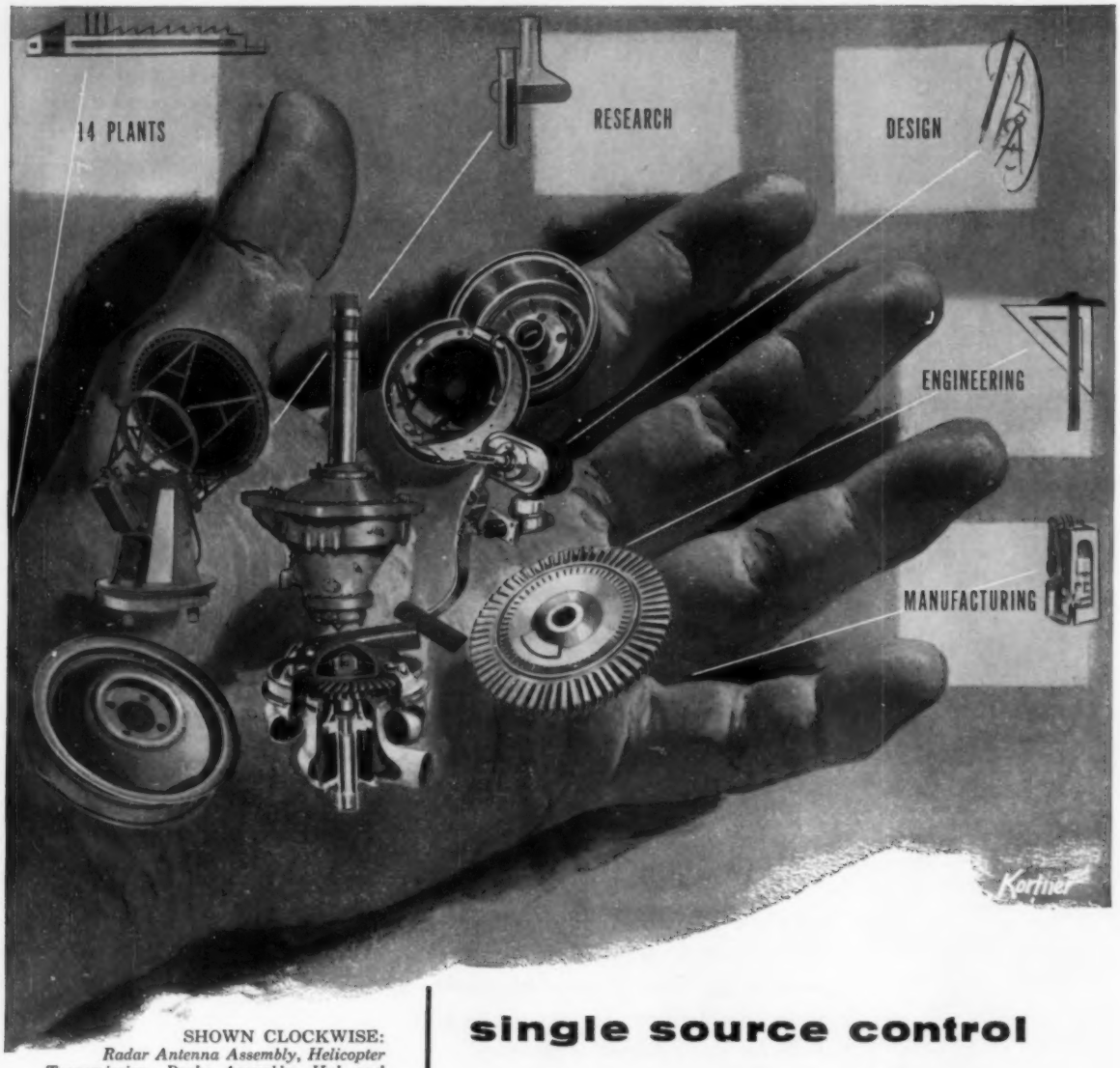
Should your requirements not be met by any of the more than 8,000 standard parts we are tooled to produce, our designers will make new tools and dies to suit your needs.

A fully equipped plating and finishing department is an integral part of our production. Send us your blueprints or other specifications for our quote and write for our descriptive catalog.

Deep-drawings

Eastern Tool & Mfg. Co.

Belleville 9, New Jersey



SHOWN CLOCKWISE:
Radar Antenna Assembly, Helicopter Transmission, Brake Assembly, Hub and Drum Assembly, Power Brake, Jet Turbine Wheel, Power Recovery Unit, Tractor Wheel.

KELSEY-HAYES PRODUCTS

automotive: Wheels, Hub and Brake Drum Assemblies, Hydraulic and Electric Brakes, Power Brakes, Transmission Bands, etc.

aviation: Jet Turbine Wheels and Compressor Rotor Assemblies, Blades, Buckets and Vanes, Power Recovery Units, Helicopter Transmissions, Actuators, Accessory Gear Assemblies, Bomb Hoists and Gun Turrets, Radar Tracking and Scanning Assemblies.

agriculture: Tractor Wheels and Components, Seeders, Wagons and other Farm Implements.

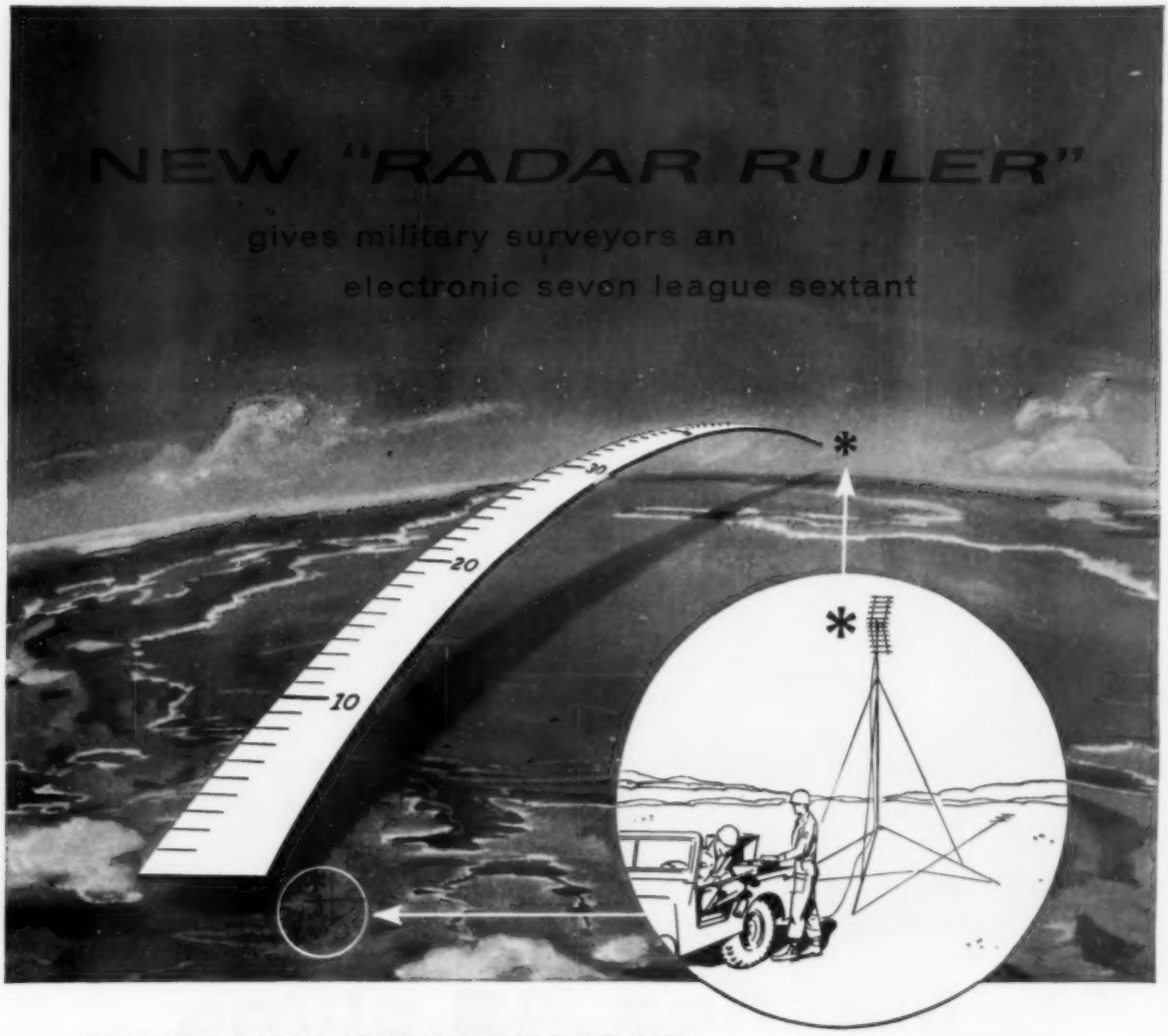
single source control

PLANNED EXPANSION makes Kelsey-Hayes a far more valuable source to the automotive, aviation and agricultural industries. Diversification of *products* provides a broader reserve of engineering and manufacturing experience to apply to related problems. Diversification of *facilities* enables Kelsey-Hayes to do a more complete job—from research through manufacturing—with all the advantages of single source control and responsibility.

KELSEY-HAYES

Kelsey-Hayes Wheel Co., Detroit 32, Mich. • Major Supplier to the Automotive, Aviation and Agricultural Industries

14 PLANTS / Automotive: Detroit and Jackson, Michigan; McKeesport, Pa.; Los Angeles, Calif.; Windsor, Ontario, Canada • Aviation: Jackson, Michigan; Springfield, Ohio (SPECO Aviation, Electronics and Machine Tool Division); Utica, New York—4 plants—(Utica Drop Forge and Tool Corporation, a subsidiary) • Agricultural: Davenport, Iowa (French & Hecht Farm Implement and Wheel Division)



PORTABLE RADAR STATIONS MEASURE AND DOUBLE CHECK 50 MILE READINGS IN SECONDS

For the *first time*, surveyors are freed from short-sighted optical equipment. Unlike old-fashioned surveying tools, the "radar ruler" pierces through fog, darkness or dense foliage, electronically pacing off distances of 1 to 50 miles, precise to within a few meters!

This new general-purpose surveying instrument was developed by Motorola's Military Electronics Laboratory for the Signal Corps Engineering Laboratories, Fort Monmouth, N. J. The entire operation can be handled easily and quickly by unskilled personnel.

This self-calibrating system uses two identical portable radar stations which bounce a signal back and forth thousands of times each second. High-speed computers automatically provide the data necessary to measure off the distance.

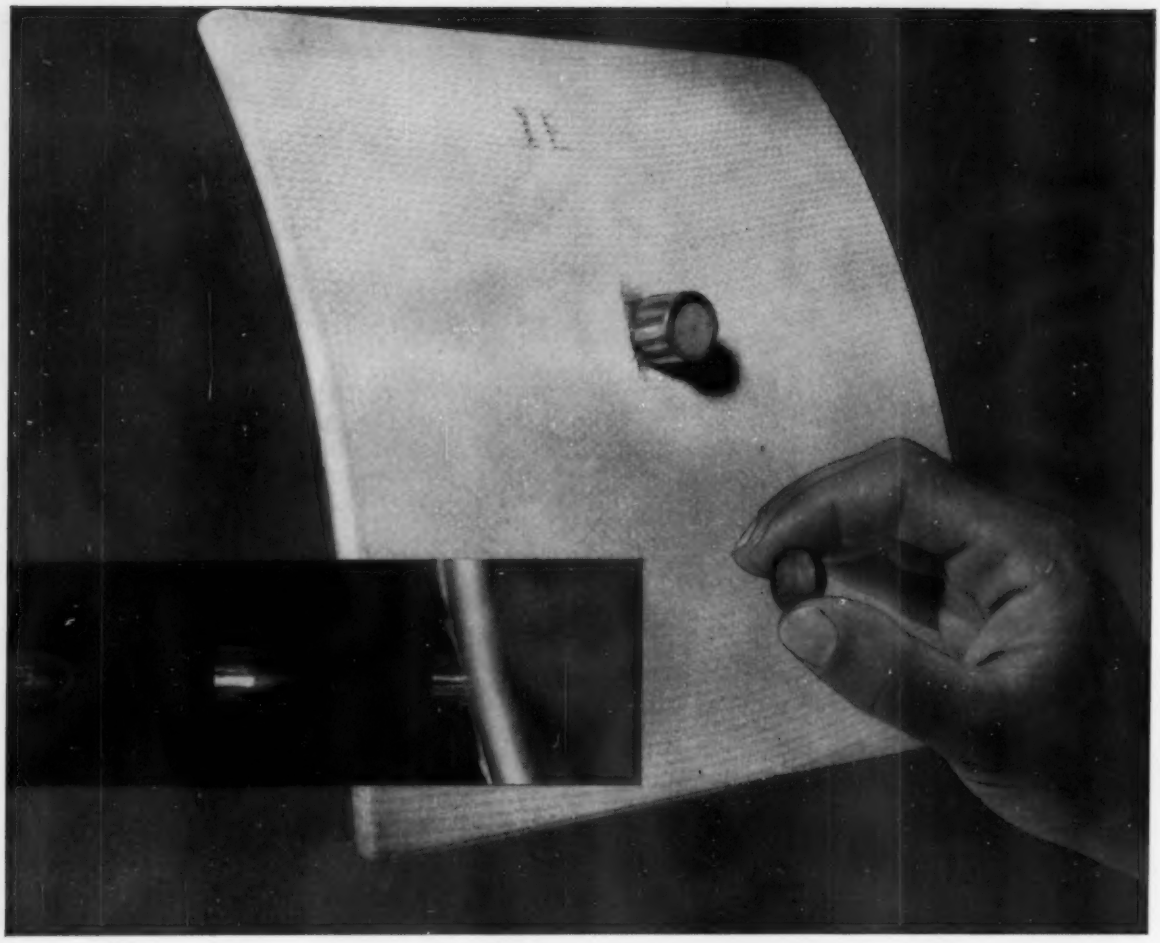
Here is just one more example of the equipment now being developed by Motorola for many varied military applications.

3 suitcases and a 25 ft. collapsible antenna comprise the entire equipment

navigational devices • radar • countermeasures • microwave systems • communications equipment
data transmission • plotting systems • telemetering • data processing and presentation indicators

Positions open to qualified Engineers and Physicists

MOTOROLA *Communications & Electronics Division*
National Defense Department
2710 N. Clybourn Ave., Chicago, Ill. Other facilities: Phoenix, Arizona and Riverside, California



Mashes .45 slugs at point blank range!

Air Cruisers plastic armor only 1/8 inch thick stops .45 calibre bullets fired from only five feet away

Battle-tested in Korea, plastic body armor reduced shrapnel fatalities by 70%. It is only one of several glass fiber polyester laminates manufactured by AIR CRUISERS. All are outstanding in their strength-weight relationships, are very easily worked and have outstanding structural possibilities.

Projected aircraft applications include protective panels for crews and engines, instrument panels, seat buckets, fairings, ammunition chutes and disposable gas tanks. These glass fiber polyester laminates, molded in either standard sheets or intricate shapes, can replace metals in stationary installations, vehicles and ships. Industrial applications of this versatile product are limitless.

We shall be happy to provide engineering consultation and assistance in adapting these materials to your present and future needs or purposes.

THE GARRETT CORPORATION

AIR CRUISERS DIVISION

BELMAR, NEW JERSEY

LIFE JACKETS • LIFE RAFTS • HELICOPTER FLOATS • ESCAPE SLIDES • PLASTIC ARMOR • POLYETHYLENE SHIELDING • RELATED SURVIVAL EQUIPMENT

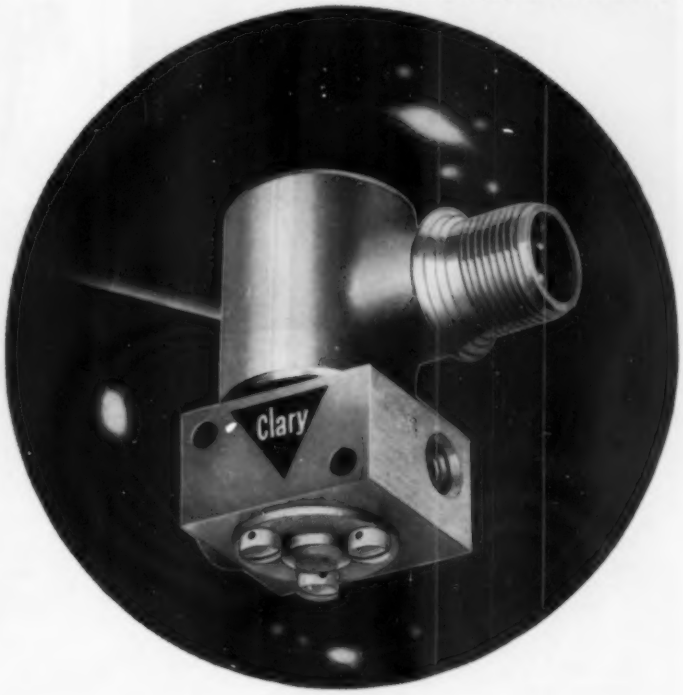
Now from Clary!

A new kind of solenoid valve for guided missiles

America's smallest, lightest, most reliable solenoid valve.

Controls air, helium, nitrogen, LOX or corrosive liquids.

Below, standard ⅛" valve with Bendix connector 10-63212-3P.



EXCLUSIVE FEATURES

Zero leakage. Internal vent to atmosphere through *controlled outlet* prevents drawing moisture-laden or contaminated air into cavity of moving parts. *Hermetically-sealed coil* assures trouble-proof operation. Solenoid may be rotated on valve body to place electrical connector in most desirable location. This same Clary valve can be used for *"normally open"* or *"normally closed"* service by simple mechanical rearrangement of the solenoid.

STANDARD VALVES*

Rated Operating Pressure: 3000 PSI
Voltage: 18-30 D.C.
Connector: Bendix 10-63212-3P
Packing: AN "O" Rings

Tube Size	Service	Part No. Normally Closed	Part No. Normally Open
DIRECT-OPERATED			
⅛"	2-way	520030	520031
⅛"	3-way	520032	520033
¼"	2-way	520034	520035
¼"	3-way	520036	520037
⅜"	2-way	520038	520039
⅜"	3-way	520040	520041
PILOT-OPERATED			
½"	2-way	520042	520043
½"	3-way	520044	520045
¾"	2-way	520046	520047
¾"	3-way	520048	520049

*Modifications available to meet design requirements.

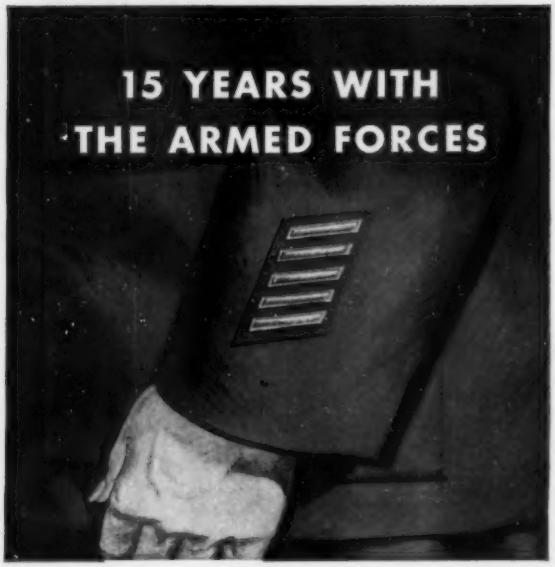
We are proud to announce a new complete line of solenoid valves to meet the most stringent environmental conditions encountered by guided missiles. Our years of experience in manufacturing guided missile components – gyroscopes, servo-actuators, propellant valves, telemetering transducers – now enable us to bring you solenoid valves built with the same precision. Our extensive inspection and quality control guarantee the maximum reliability required of missile components.

Clary AUTOMATIC CONTROLS DIVISION

Clary Corporation, Dept. NA116, San Gabriel, California

MANUFACTURER OF BUSINESS MACHINES, ELECTRONIC DATA-HANDLING EQUIPMENT, AIRCRAFT AND MISSILE COMPONENTS

PYLE-NATIONAL



IN RESEARCH, ENGINEERING AND MANUFACTURING

For a decade and a half Pyle-National has engineered and manufactured electrical and electro-mechanical systems and components for the military. Today all of the skills and facilities developed at Pyle-National during this association, are available to meet your problems. The following special product's bulletins are representative of items developed and produced to meet military needs.

U. S. ARMY Type Junction Boxes . . .

submersible, available in various types and sizes. All may be furnished with receptacles.

U. S. NAVY Type Connectors . . .

available in 2 to 18 pole combinations. All contact units are interchangeable and reversible.

U. S. AIR FORCE Type Connectors . . .

watertight pin & socket and coaxial combinations in 2 to 92 pole. Similar units for Army specifications.

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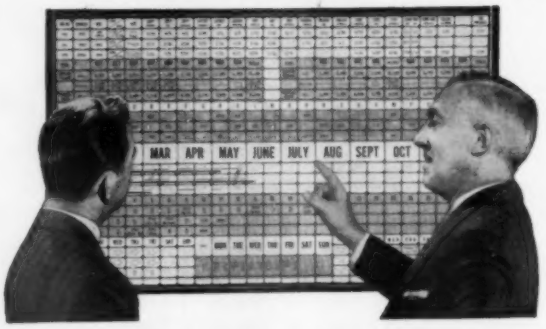
Midland, Michigan, Dept. 8311c.

You Get Things Done Better By Seeing What's Happening



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FULLY AUTOMATIC RADAR FIRE CONTROL

EQUIPMENT FOR 57 mm AND 40 mm A A GUNS

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HENGELO (O) - NETHERLANDS

NEW THIOKOL ROCKET MOTOR PLANT TO BE BUILT IN NORTHERN UTAH

12,000-acre plant site acquired for rocket motor development center

Near the north shore of Utah's Great Salt Lake a new Thiokol plant will soon rise. This latest expansion by the Thiokol Chemical Corporation will bring to four the total number of Thiokol plants devoted exclusively to the development and production of solid propellant rocket motors.

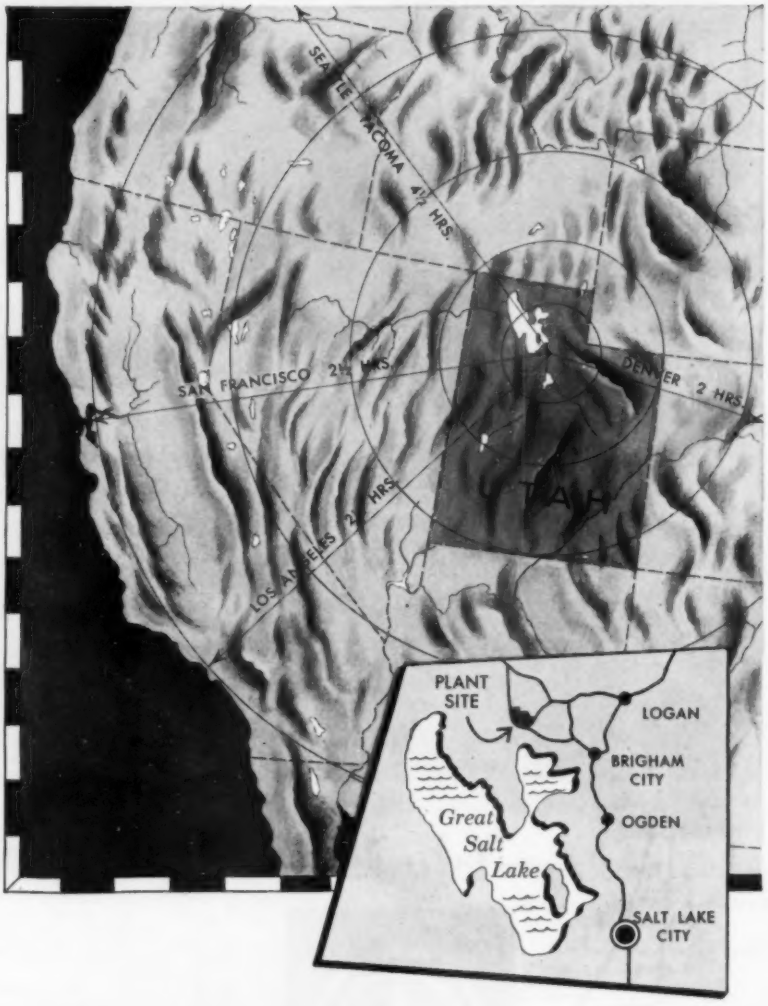
Just 84 miles northwest of Salt Lake City, the new site is centrally located with regard to all major western cities. It is convenient to both rail and air transportation, yet sufficiently isolated to permit the testing of the largest rocket motors.

Thiokol chose this location in order to service the growing missile and rocket industry in the West. It will become Thiokol's western center for all guided missile engines and rocket motor development and production.

Engineers and Chemists – *become a member of Thiokol's rocket development and manufacturing team. We welcome inquiries from mechanical engineers, chemical engineers and chemists interested in the rocket field.*

If you would like more information about the Thiokol Chemical Corporation, write on your business letterhead for our booklet, "From Rubber to Rockets"— the story of Thiokol, as a synthetic rubber and rocket propellant pioneer.

THIOKOL CHEMICAL CORPORATION
780 NORTH CLINTON AVENUE,
TRENTON 7, N. J.

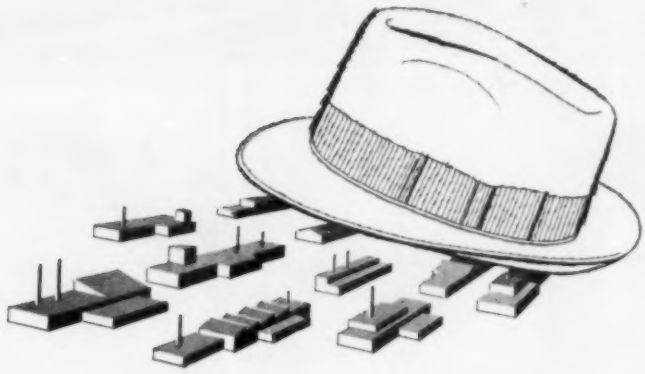


Thiokol®

Rocket Divisions now at
ELKTON, MARYLAND • HUNTSVILLE, ALABAMA • MARSHALL, TEXAS

HOW ACF
BREAKS THE TIME BARRIER
IN DEFENSE PROJECTS WITH

22 plants under one 'hat'!



Diversified *facilities*...unified *control*...that's how ACF cuts months from major defense production schedules.

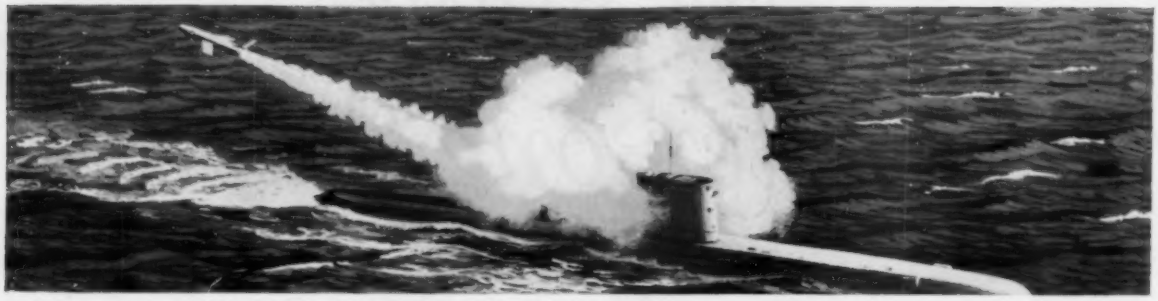
Each of the 22 ACF plants draws on the many specialized skills and facilities of all the others, yet clear responsibility is assured. Central administration of engineering and production minimizes coordination and planning problems. As a result, ACF has made, and continues to make, outstanding records in nearly every field of defense production.

For further information about ACF Industries' engineering and production ability, why not call or write any ACF office today.

ACF
INDUSTRIES, INCORPORATED
30 Church Street, New York 8, N. Y.
Serving America Through Integrated Facilities

Divisions: American Car and Foundry, Avion, Carter Carburetor, Erco, Nuclear Energy Products, Shippers' Car Line, W-K-M.

1 Submarine surfaces near enemy coast...



2 ...launches *Regulus* guided missile...

3 ...*Regulus* streaks toward target...

4 ...submarine dives, no trace remains.

Airborne Thunder

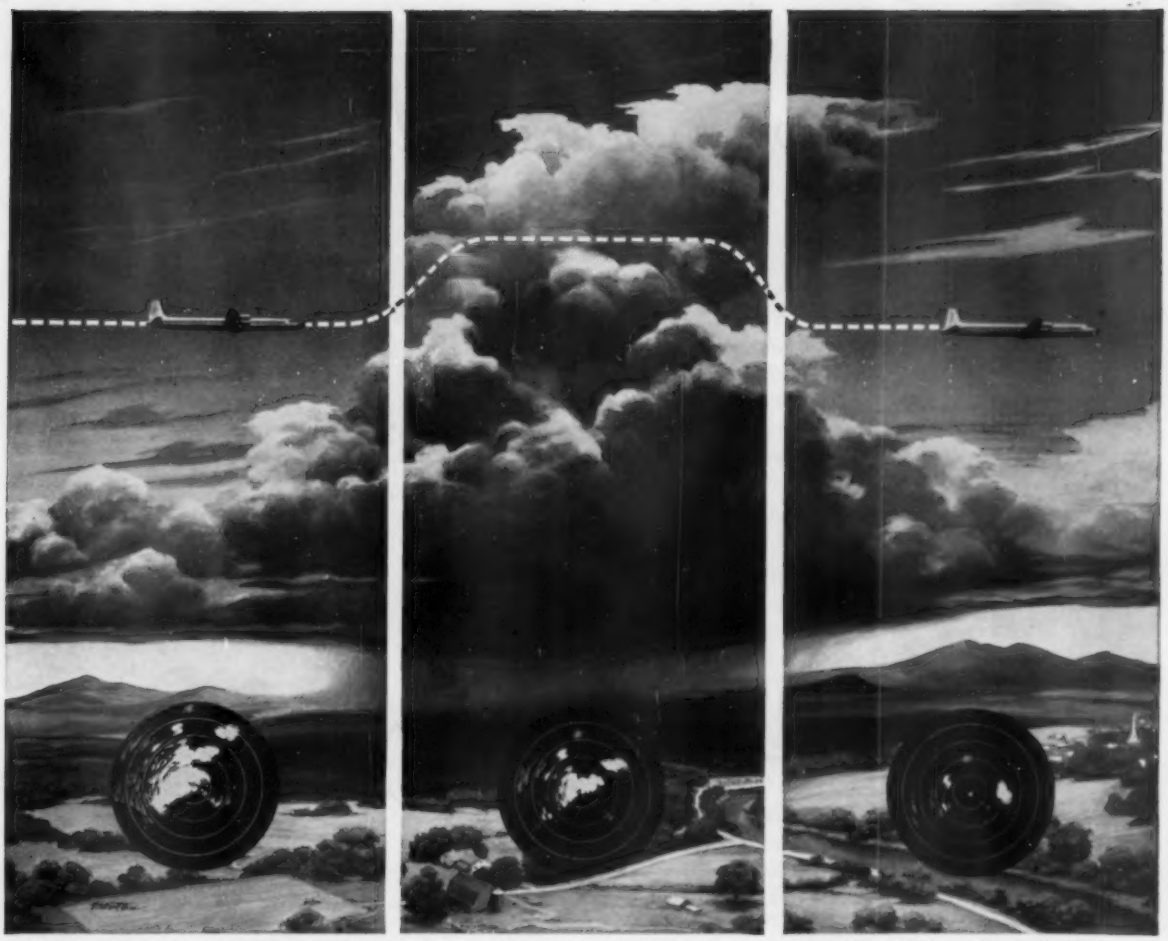
for the Silent Service

Regulus guided missiles now make aircraft carriers out of Navy submarines. This new weapons team is typical of Navy's Nuclear Age tactical power. Carried invisibly to enemy shores, launched against a target far inland, *Regulus* gives your New Navy an *intercontinental capability today!* Designed and built by Chance Vought Aircraft, *Regulus* is a prime example of the dependability and accuracy that makes new Navy weapons and techniques increasingly important to a strong U. S. Defense Team.

Scientists and Engineers: There is a challenging place for you on Vought's creative team now. For details write: J. W. Larson, Assistant Chief Engineer, P. O. Box 5907, Dallas, Texas.

CHANCE VOUGHT AIRCRAFT
INCORPORATED · DALLAS, TEXAS

DESIGNER AND BUILDER OF HIGH PERFORMANCE MILITARY AIRCRAFT SINCE 1917



RCA Weather Radar screen shows approach of storm. Screen guides pilot around turbulent area. All's well as plane leaves storm behind.

How RCA Weather Radar adds comfort and speed to your flight

No longer need you, as a traveler of the sky, experience the discomfort of bouncing around during storms. If your plane is equipped with RCA Weather Radar, you enjoy comfort and speed throughout—because the plane can by-pass turbulent elements.

Supersensitive RCA radar peers miles ahead of the plane to give your pilot advance warning of weather disturbances. Signals on its screen then point the way to a smooth course around storm areas saving precious minutes and miles.

The electronic leadership behind Weather Radar is inherent in all RCA products and services. And at the David Sarnoff Research Center of RCA, Princeton, N. J., scientists continue to explore new "Electronics for Living"—electronics that make life easier, safer, happier.

LEADING AIR LINES installing RCA Weather Radar include American Airlines, Continental Air Lines, Pan American World Airways, Trans World Airlines Inc., United Air Lines; and these European Air Lines: Air France, BOAC, Iberia Air Lines of Spain, Sabena Belgian World Airlines, Swissair; Mexicana.

RADIO CORPORATION OF AMERICA

ELECTRONICS FOR LIVING

Q: *How to heat vehicles?*

Q: *Chilly day at Thule (−50°F.) . . . how to start fire-crash truck within seconds, provide 90,000 Btu/hr. in small space?*

A: Janitrol liquid heater (tested to −65°F.) keeps engine ready to go, provides cab and cargo heating too!

Q: *How to find money to build heated storage buildings for Diesel bus fleet?*

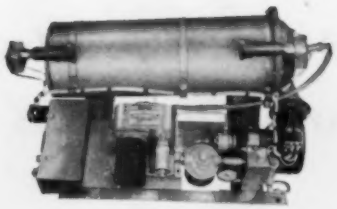
A: No need to find it, park the fleet outside —Janitrol liquid heaters keep engines, and bus interiors warm, ready to go at a fraction of cost of new building.

A:

A: Call on Janitrol. If there's a need for heat for the job anywhere, chances are Janitrol can supply it, or build it from service-proved components.

Ever since designing and manufacturing the first successful heaters for aircraft 14 years ago, Janitrol has built thousands of heaters for aircraft and ground vehicles.

Today the name Janitrol stands for leadership in heating equipment and combustion engineering. Your Janitrol representative is always at your service.



Janitrol

AIRCRAFT-AUTOMOTIVE DIVISION, SURFACE COMBUSTION CORPORATION, COLUMBUS 16, OHIO

DISTRICT ENGINEERING OFFICES: WASHINGTON, D.C., PHILADELPHIA, COLUMBUS, FT. WORTH, HOLLYWOOD

rockets give helicopters extra lift

Reaction Motors, developer and producer of rocket engines and powerplant systems for guided missiles, aircraft, and ordnance-type rockets, is an important participant in the OMAR program. With Marquardt Aircraft, the West's largest jet engine research and development center, and Olin Mathieson Chemical, RMI contributes to a continuous joint technical effort to advance the science and technology of supersonic powerplants and fuels.

The OMAR program illustrates the integration of effort by a well-coordinated industrial team . . . the weapons systems concept in action. This combination of technical and production skills, products, services, and corporate strength has the capacity to provide an effective assist to those responsible for the common defense.

Engineers, chemists, physicists, production and tool specialists . . . a wide variety of fascinating careers await you on this weapons systems team. For information write OMAR Employment Officer at the company nearest you.

Tiny rotor-tip rocket engines increase the payload of the Sikorsky HRS-2 helicopter up to 100 per cent. Having started their vertical take-offs at same instant, equally heavily loaded Marine helicopters demonstrate relative hovering capabilities. Standard HRS-2 (background) hovers only as high as ground effect will permit. ROR (rocket-on-rotor) helicopter climbed straight up through ground effect and was still climbing when this photo was taken. Developed by Reaction Motors, Inc., for the Navy, ROR provides auxiliary power for take-off or emergency situations.

Marquardt Aircraft Company
Van Nuys, California

Olin Mathieson Chemical Corporation
New York, New York

Reaction Motors, Inc.
Denville, New Jersey

MARQUARDT AIRCRAFT
OLIN MATHIESON CHEMICAL
REACTION MOTORS

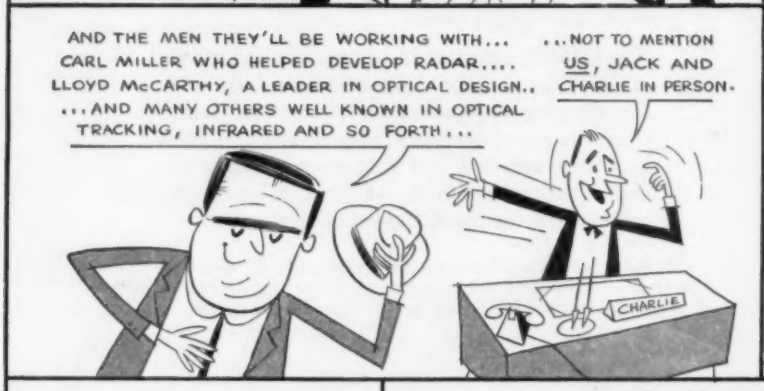
OMAR

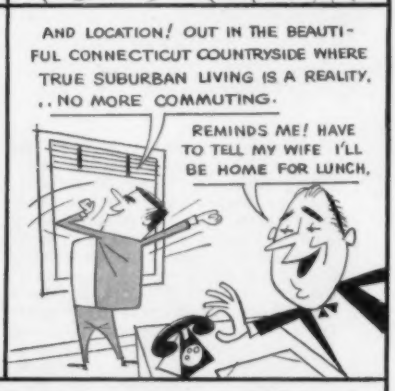
PERKIN-ELMER'S

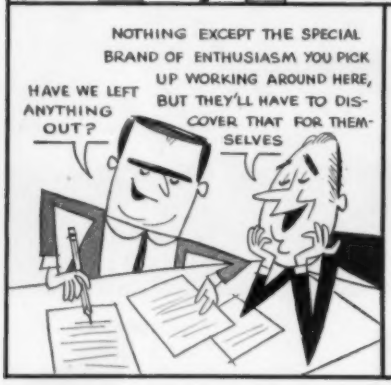
Jack and Charlie

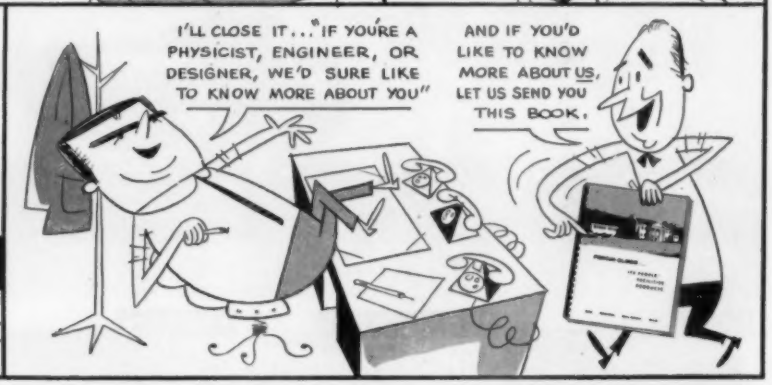
EASY, CHARLIE, I'M TRYING TO WRITE A "HELP WANTED" AD THAT GETS ACROSS ALL THE THINGS P-E CAN OFFER GOOD ENGINEERS AND PHYSICISTS...
ADVERTISEMENT? WELL LET OL' GRAY FLANNEL CHARLIE HELP YOU WITH IT.

FIRST OF ALL, LET'S TELL 'EM WHAT PERKIN-ELMER DOES... DESIGNS AND PRODUCES FINE OPTICS, INFRARED INSTRUMENTS, ELECTRO-OPTICAL WEAPONS SYSTEM....
...TO SAY NOTHING OF SECRET INFRARED DETECTOR STUFF.


AND THE MEN THEY'LL BE WORKING WITH... CARL MILLER WHO HELPED DEVELOP RADAR.... LLOYD McCARTHY, A LEADER IN OPTICAL DESIGN.. ...AND MANY OTHERS WELL KNOWN IN OPTICAL TRACKING, INFRARED AND SO FORTH...
...NOT TO MENTION US, JACK AND CHARLIE IN PERSON.
CHARLIE


AND LOCATION! OUT IN THE BEAUTIFUL CONNECTICUT COUNTRYSIDE WHERE TRUE SUBURBAN LIVING IS A REALITY. ..NO MORE COMMUTING.
REMINDS ME! HAVE TO TELL MY WIFE I'LL BE HOME FOR LUNCH.


HAVE WE LEFT ANYTHING OUT?
NOTHING EXCEPT THE SPECIAL BRAND OF ENTHUSIASM YOU PICK UP WORKING AROUND HERE, BUT THEY'LL HAVE TO DISCOVER THAT FOR THEMSELVES


I'LL CLOSE IT..." IF YOU'RE A PHYSICIST, ENGINEER, OR DESIGNER, WE'D SURE LIKE TO KNOW MORE ABOUT YOU"
AND IF YOU'D LIKE TO KNOW MORE ABOUT US, LET US SEND YOU THIS BOOK.

Perkin-Elmer is a diversified, growing young company, well known to both industry and defense people. Why not send our personnel manager a resume of your qualifications. And if you'd like, we'll send you a copy of "Perkin-Elmer . . . its people, facilities, products."

Engineering and Optical Division

Perkin-Elmer *Corporation*

Norwalk, Connecticut

100 WATTS

. . . from 28v DC input
. . . from 115v,
400 cps AC input

WEIGHT AND SPACE SAVING COMPLETELY ELECTRONIC POWER SUPPLIES FOR AIRCRAFT RADIO RECEIVERS, TRANSMITTERS, COMPUTERS, SMALL INSTRUMENT SERVOS

UAC offers a complete range of compact power supplies: 1, 5, 10, 25, 50, 75, 100 Watts (500 Watts for special uses) . . . DC to DC . . . AC to DC . . . DC to AC for use in intercoms, radiosonde, telemeters, or wherever highly efficient portable power is required.

UAC DC POWER SUPPLY (SHOWN ABOVE) DELIVERS 50W FROM 28v INPUT

100 WATT DC-DC: 3" x 3" x 6"; 3 lbs.
100 WATT AC-DC: 3" x 3" x 6"; 3 lbs.
Efficiency to 90% or more
Regulated or unregulated
Rugged to meet military specifications

Write, wire, phone specifications today on your current production. Also ask for information about UAC transistorized radiation detection instruments.

Universal Atomics Corp.

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EDgewood 3-3304

SU-10 SENSATER *hook scale. Accurate. Friction free. Rugged.*

SB-10 CRANE WEIGHT INDICATOR *tells total weight, boom radius, and capacity at each radius.*

S-8 CRANE WEIGHT INDICATOR — *small, low cost, remote reading, for use on all types of cranes.*

J-701 TENSIOMETER *unitized instrument, used as traction dynamometer, suspension scale, etc.*

J-702 TENSIOMETER *remote indicating dynamometer, suspension scale, cable strain equalizer, etc.*

LIFT TRUCK SCALE *makes any hydraulic-cylinder-type lift truck a scale, assures full, safe load.*

STANDARD TENSION INDICATOR *used as dynamometer or for equalizing strain on cables, wires, etc.*

HEAVY-DUTY TENSION INDICATOR *for use on ¾" to 1 ¾" wires and cables; has 200,000-lb. capacity.*

Any tanks to test today?

Whether you want to test the pulling power of the winch on an amphibious tank (as shown in the photo), the tensile strength of a piece of equipment, or the weight of material being loaded aboard a vehicle, or if you need a safety device to tell you if you're overloading your materials-handling machinery, Martin-Decker manufactures the heavy-duty hydraulic instruments that can give you the precise answers you need.

Write for free literature, prices, and other data about Martin-Decker's crane weight indicators, lift-truck scales, tensiometers, hook scales, and tension indicators. The address: Martin-Decker Corporation, 3431 Cherry Ave., Long Beach 7, Calif.

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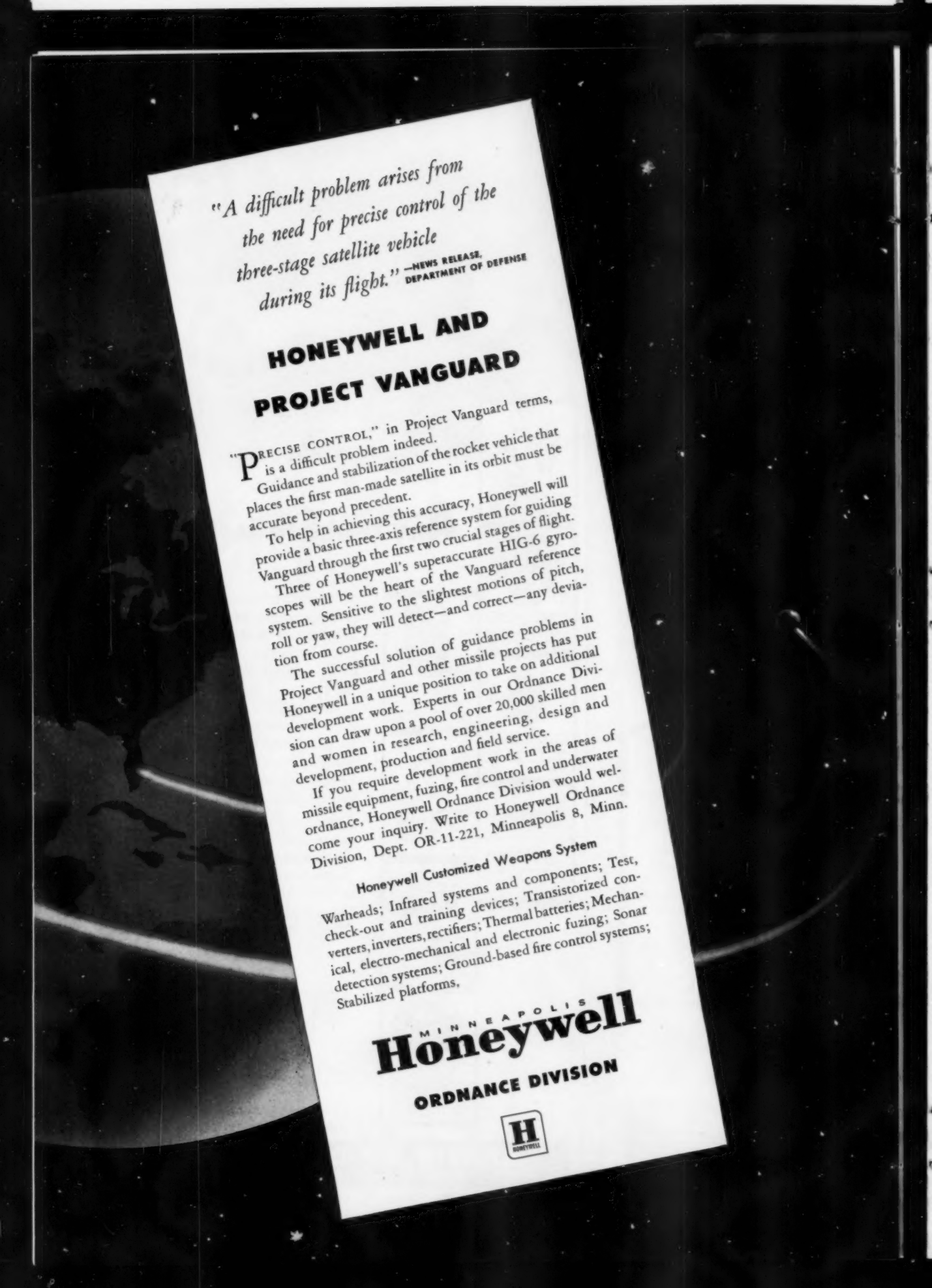

"A difficult problem arises from the need for precise control of the three-stage satellite vehicle during its flight." —NEWS RELEASE, DEPARTMENT OF DEFENSE

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ARMAMENT TECHNOLOGY

This section of ORDNANCE contains selected papers presented at meetings of Technical Divisions and Committees of the American Ordnance Association and contemporary articles on armament research, development, manufacture, and field use

Programming Analysis

Procedure for using management statistics at the Anniston Ordnance Depot

Dr. Harold E. Klontz

Professor of business statistics, Alabama Polytechnic Institute, Auburn, Ala.

RECENT articles in ORDNANCE have stressed the necessity for industrial mobilization planning. For example, William J. Meinel in his article, "Trends in Preparedness" (ORDNANCE, July-August 1955), emphasizes the necessity of having industrial personnel and facilities ready for rapid conversion to war production. Difficulties inherent in industrial mobilization would be minimized by making full use of mobilization planning.

Accompanying industrial mobilization there would have to be a corresponding mobilization effort on the part of the Ordnance depots which are the vital link between the industrial producers and the armed forces' users for many ordnance items. This mobilization effort must be planned, and the planning of necessity must have a sound factual basis.

AS James H. Healey writes in the April 1955 issue of *Armed Forces Management:* "Planning is the study of the future, immediate or distant, and the evolution of a series of proposals for action. It results in a business plan or a plan of action. This plan of action will be a synthesis of considerations of past performances or occurrences, the present situation, and a forecasting of the future."

The purpose of this article is to describe programming analysis—a procedure for collecting and using management statistics—which has been in operation at the Anniston Ordnance Depot, Anniston, Ala., since August 1954. This procedure is designed to provide a sound factual basis for management decisions, whether they are made in time of peace or in war.

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As a consulting statistician during the summers of 1954 and 1955 at the Anniston Ordnance Depot, I have had a part in developing programming analysis and an opportunity to witness it in action.

The Anniston Ordnance Depot is located ten miles from Anniston in the northwestern part of Alabama approximately halfway between Birmingham and Atlanta. Construction of the depot was begun with a ground-breaking ceremony on February 17, 1941. For the first two years of its existence the depot was operated by the Ordnance Department.

THE Chrysler Corporation assumed management of the depot on October 16, 1943, and operated it until September 3, 1945, when it was transferred to full Army control again.

The depot covers 15,000 acres and contains approximately 1,350 buildings. Anniston is one of the country's four largest depots distributing both general supplies and ammunition. Its principal missions are distribution of ordnance general supplies and ammunition to the Third Army Area and maintenance

of combat vehicles, artillery, small arms, fire-control material, and transport vehicle subassemblies.

Prior to the summer of 1954, top management personnel apparently did not have adequate factual information at their fingertips and often did not have a sound statistical basis for their decisions. Statistical data required for off-depot reports were available and reasonably accurate but were in no way adequate for management-control purposes.

I ARRIVED at the depot June 14, 1954, and was attached to the Program Review and Analysis Branch (PR&A) of the comptroller's office which is charged with the responsibility of supervising the depot's statistical activities. As I viewed my assignment I was to assist in promoting operations research at AOD.

There are four stages in the development of operations research: (1) The collection of relevant data; (2) A study of the data to determine the interrelationships of the variables; (3) The formation of a theory to explain these relationships; and (4) The use of the theory to make predictions for future use.

To institute a means of collecting relevant management data was the first order of business. What was desired was for each division and office to maintain a complete statistical record of production data which would serve as a basis for forecasting the future work load. This forecast would then serve as a basis for work scheduling.

The procedure decided upon at the Anniston Ordnance Depot is called "programming analysis." The basic idea is that each division and office will maintain in a single volume a complete statistical record of its past and present operations and forecast of future work load. Basically, each division and office chief is required to forecast his future work load, to program or schedule this work, and to analyze his production compared with the forecast.

DIRECTIVES issued have purposely told division chiefs what to do but have not indicated in detail how to do it. The thinking in this respect is that greatest benefit will be derived if the division chief is required to analyze his operations and not merely follow a procedure which is spelled out in minute detail for him.

The great variety of activities performed at AOD precludes absolute uniformity. Division chiefs, for instance, have been directed to forecast each important element of the division's work load without being given a procedure for making the forecast.

One of my principal tasks at AOD has been to offer suggestions to each division and office chief as to what statistical method (*e.g.*, correlation, trend extension, moving average) seemed most suitable in arriving at a sound forecast of his work load. In these personal conferences I would do some indoctrinating, some teaching, and some persuading. My intention has been to create a desire for real statistical analysis of their data strong enough so that the chief will request such statistical service from the Program Review and Analysis Branch (PR&A).

I HAVE also spent considerable time assisting the statistical clerks of PR&A in performing this analysis. To enable PR&A to render this computational service most effectively, detailed procedure sheets were prepared for the computation of a variety of statistical measures.

In order to secure some degree of uniformity of presentation, it has been specified that each division programming analysis would contain as a minimum the following information in the following order: (1) Organization and manning charts, (2) functional statement, (3) personnel and leave data, (4) facilities, (5) work load and forecast, (6) comparison with other distribution depots, (7) management improvement, (8) work simplification, (9) major administrative policies (division), (10) external reports, and (11) a monthly written review and analysis (by division chief).

All divisions and offices prepare programming analyses. These range from the Provost Marshal's Office and the Quality Control Office to the Ammunition Storage Division. In addition, each branch of the Comptroller's Office and each branch of the Miscellaneous Services Office (MSO) maintains its own. Altogether twenty-four divisions, offices, and branches prepare programming analyses.

The heart of programming analysis is the work load and forecast. This section contains charts showing past production data and also forecast work load for the following six to twelve months. All activities which can be forecast are expected to be forecast and charted.

EACH month actual production is plotted on the same chart as the forecast so that the division chief can readily review his operations by comparing accomplished work load with anticipated or programmed work load. Problem areas can be discerned readily and an analysis of causes and possible remedies made.

The division chief each month is required to review his operations and place in the programming analysis book a written analysis of the past month's production; *i.e.*, how well he accomplished what he had previously programmed or scheduled.

Three copies of the programming analysis for divisions under the Assistant for Supply Operations (ASO) are prepared and distributed as follows: one copy for division, one copy for ASO, and one copy for the comptroller. The branches of the MSO also prepare programming analyses in triplicate and distribute them as follows: one copy for the branch chief, one copy for the chief of MSO, and one copy for the comptroller. All other divisions and offices prepare two copies of their books: one for the division or office chief and one for the comptroller.

THE comptroller has a complete set of the programming analyses in his office. These, of course, are available to the commanding officer at any time. The Program Review and Analysis Branch, however, extracts the most most important data from all divisions and compiles a special programming analysis for the depot commander. Virtually all work load forecast charts are included in this book.

Maj. Gen. J. H. Hinrichs, in his letter of May 6, 1954, to Col. C. J. Williams, commanding officer of AOD, states: "It is essential that the commanding officer have readily available to him a visual (charted) translation of the management statistics maintained with regard to each of his major missions.... It is essential that he know where he

has been, where he is, and where he is going, with regard to the programs at his depot."

An important development accompanying programming analysis is the system of command briefings. Not only does the commanding officer have current data readily available in his programming analysis book, but in addition he is briefed personally by each division and office chief.

Most divisions and offices have monthly briefings while a few whose operations are rather stable have quarterly briefings. PR&A schedules the command briefings, which require a maximum of only six hours a month.

In a command briefing, a division chief sits in the depot commander's office and personally briefs the commander upon the performance of his division during the past month. The comptroller and the chief of the Program Review and Analysis Branch attend each command briefing. In addition, the assistant for Supply Operations attends the briefings given by the operating divisions and the assistant for Administration and Services attends the briefings given by the divisions and offices under his supervision.

THE command briefing procedure is uniform. The division chief places before the depot commander a copy of his programming analysis. The chief then reviews his operations for the past month, giving particular attention to a comparison of forecasted work load and actual work load and reviews his plans for future months. If there is a substantial difference between forecasted and actual production the reason will have been noted on the face of the chart and any additional explanation needed is given by the division chief.

A stenographic record of each briefing is made and forwarded to each division and branch chief concerned. These briefing minutes serve as a guide to future action. Policies and decisions stated therein are expected to be put into effect immediately and questions raised are answered as soon as possible.

The system of command briefings is probably one of the most important developments at Anniston Ordnance Depot. Not only is the commanding officer kept fully informed, but each division chief must be so familiar with the performance of his division each month that he can give the depot commander a detailed description and answer any questions raised.

Command briefings are entirely different from the usual executive council meetings at which all division and office chiefs meet with the commanding officer and attempt to brief him at one time on broad over-all policy and items affecting the entire depot.

Step one in the operations research program has been fairly well developed. The procedures exist now whereby most data originating on the depot are collected and recorded. There is need, however, for data originating elsewhere, for example certain Third Army data, to be assimilated into programming analysis.

IT is realized that at AOD we have attempted to jump from operations research step one (collecting data) to step four (forecasting) without going through the other steps which are required for absolutely sound forecasts. All too often during the past year, forecasts have been entirely subjectively and perhaps arbitrarily made. Really sound forecasts probably will not be made until the statistical analysis required by steps 2 and 3 has been performed.

However, in an attempt to place the forecasts on a sounder logical basis immediately, the most recent local directive concerning preparation and use of programming analysis specifies:

1. Assumptions upon which forecast is made will be stated.
2. If actual work load differs substantially from forecast, the assumptions used in arriving at the forecast should be critically reviewed.
3. In the above situation it should be determined whether the upsetting factor or factors could reasonably have been anticipated.

PR&A is also attempting to obtain the widest practicable use of a new charting technique which provides an objective method of evaluating the validity of the forecast. This charting technique makes use of control limits so widely used in quality-control charts. With control limits drawn above and below the forecast line, it is a relatively simple matter to discover whether the actual production is following the forecast pattern.

What we shall attempt to do in the near future is to proceed to step two in our operations research program and discover the interrelationship existing between variables; *e.g.*, the relation between number of troops stationed in the Third Army Area and quantity of ordnance supplies shipped. We are now attempting to discover by statistical analysis the mathematical constants expressing the relationship between principal cause-and-effect factors.

Program Review and Analyisis is prepared to provide most of the computational service required. It is anticipated that sometime in the near future PR&A personnel, after suitable training, will be able to apply mathematical or linear programming to Anniston Ordnance Depot. When that takes place it will mark the highest development in operations research.

Programming analysis, as we call our version of operations research at AOD, is far from being complete or perfect. Further improvements are planned and are expected to occur in the near future. It is our expectation that if this country is called upon to mobilize, management personnel at AOD will have a sound statistical base for their decisions.

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Cross-wind Launching

The Naval Ordnance Test Station at China Lake, Calif., has developed new techniques for testing the effects of wind on rockets and projectiles as they are fired at both low and high speeds from moving platforms

Dr. George Leitmann

IN order to permit the study of the behavior of projectiles and rockets when launched into an air stream in motion with respect to the launcher or projector, various techniques have been developed both to accomplish the launching and to obtain the required data. Operationally, firing into a moving air stream takes place whenever a missile is launched from a moving projector into a stationary air stream, or from a stationary projector into a moving air stream, or when a combination of these circumstances occurs.

The velocity of the air stream with respect to the launcher may be relatively low, as in launchings from shipboard, or it may be very high, indeed, as in the case of firings from high-speed aircraft.

In what follows, we shall survey briefly some of the methods that have been used at the Naval Ordnance Test Station, China Lake, Calif., to accomplish both low- and high-speed launchings as well as various techniques utilized in obtaining required information on the behavior of missiles.

THE subject matter divides naturally into two main topics: (1) Means of propulsion and tracks and (2) Required data and techniques for obtaining them. Topics will be discussed in the foregoing order. Finally, an actual experimental setup will be discussed to illustrate the methods outlined.

To carry out firings at moderate speeds, launchers have been mounted on vehicles that travel on railroad tracks. A railroad spur line situated at NOTS has been improved to reduce vibration and instability induced by unevenness in the roadbed. Straight stretches of track were chosen as launching sites in such a way as to allow firing around the clock. From these sites missiles having a range up to 10,000 yards may be launched. This facility is known as the K-3 range.

Dr. Leitmann is head of the Aëroballistics Analysis Section, U. S. Naval Ordnance Test Station, China Lake, Calif. This article is taken from a paper presented at the Seventh Tripartite AXP Conference held at the Naval Ordnance Laboratory, White Oak, Md.

During the early days of this range's history, launchers were mounted on standard railroad work cars, known as Buda cars. These are small, gasoline-engine-powered vehicles capable of a maximum speed of about 35 knots. Because of their limitations, only relatively small items could be fired at low speeds.

When the need for larger platforms capable of traveling at higher speeds arose, a special prime mover (Fig. 3) was acquired which can pull a flatcar with launcher and associated equipment weighing over 4,000 pounds at speeds up to 50 knots. The prime mover is powered by a standard Buick engine and is streamlined to attain low-turbulence air flow over the launcher mounted on the flatcar behind it.

Both Buda car and prime mover are unmanned during the launching. Firing is accomplished by remote control, in most instances by means of a third rail supplying the firing pulse. Both vehicles are brought to a stop by brake trips along the track. While instrumentation of the Buda cars was rather rudimentary, the prime mover is equipped with a host of automatic features (including five ways of halting the vehicle) to ensure safe and trouble-free operation.

AS an auxiliary means for low-speed launchings for which precise knowledge of launch position and velocity is not required, a truck and trailer arrangement has been devised. The launcher is mounted on a semitrailer pulled by a truck. Driver and assistant are protected by an armored cab, and firing is initiated by a signal from the cab. Traveling on a straight road with favorable incline, this arrangement can be utilized for speed runs of up to 40 knots.

Rocket-propelled sleds constitute the primary means for accomplishing high-speed launchings well into the supersonic range. These sleds are of a multitude of designs, depending on the launcher they are intended to carry and on the speeds they must attain. They may be powered by a few or a

great many rockets of various sizes.

The sleds travel on a number of tracks available at NOTS. K-2 track is a narrow 2-rail affair, 1,500 feet in length. Firings at speeds up to 3,000 feet a second have been carried out on this track.

The B-4 range has a wide (railroad) gauge track 14,500 feet in length, allowing speeds in excess of 1,900 feet a second. The longest and most elaborate track at NOTS is the Snort, wide-gauge, double-rail, and presently 4.1 miles in length.

Cross-wind firings constitute just one of a great many missions carried out at this facility. In the course of some recent experiments a speed of over 1,850 feet a second was reached on Snort. On all these tracks sleds are brought to a stop by frictional coasting, sand and water brakes, and by retro-rockets. From one or more of these tracks missiles having ranges up to 5,000 yards may be launched.

In all instances, firing is automatic, either via third rails or screen boxes. Intelligence such as camera timing is carried to the moving launching platform by direct pickup from third rails and telemetering equipment.

WHILE it is beyond the scope of this paper to discuss the significance of data obtained from launchings off a moving platform, it may be of some interest to say a few words regarding the methods used in gathering these data.

Among the necessary basic information are the position, velocity, and acceleration of the launcher at the time the missile emerges; *i.e.*, at the instant it embarks on its unconstrained trajectory. These quantities can be measured in various ways: photography, magnetic pickups, carbon-rod make-break circuits, third rails, etc. Accuracies of plus or minus 0.1-foot in position, 1.0 foot-second in velocity, and 30.0 foot-seconds per second in acceleration can be attained.

In order to determine malpointing and mallaunch, a knowledge of the angular orientation, velocity, and acceleration of the launcher tube or rails at the time of missile emergence is required. The so-called "optical-lever technique" has proved to be a very accurate method for obtaining angular orientation.

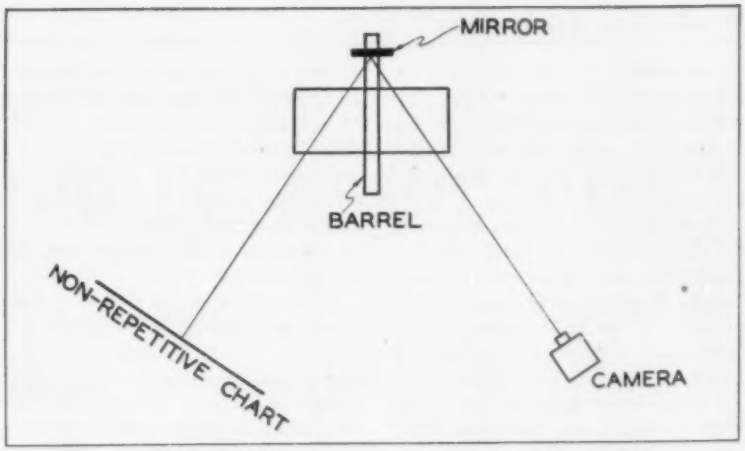


Figure 1. The optical lever system for obtaining angular orientation.

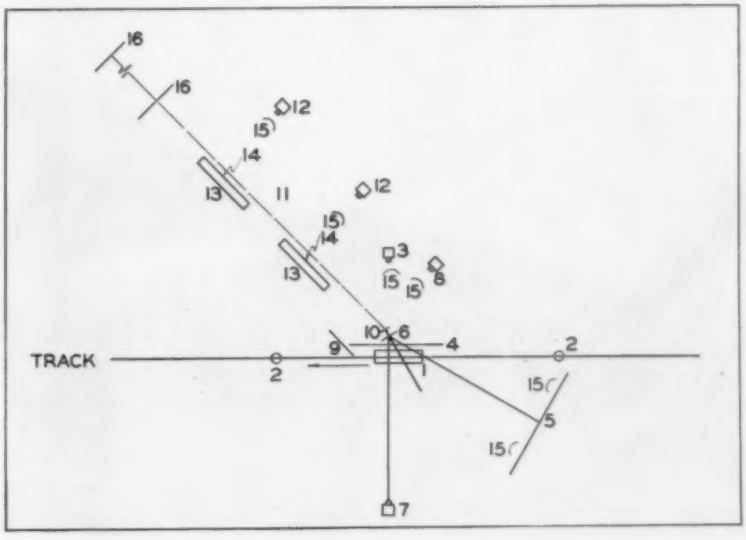
The following apparatus is employed here: One or more mirrors mounted on the launcher, one or more nonrepetitive charts—*i.e.*, charts bearing an easily readable pattern whose symbols unambiguously identify the position of points on the charts—microflash lamps and associated equipment, and open shutter, high-speed moving-film cameras.

The optical lever (Fig. 1), in question extends from a point on the chart to the mirror on the launcher and thence to the camera. Whenever a microflash lamp illuminates the nonrepetitive chart (and this may occur 2,000 times a second), the image of the part of the chart visible in the mirror at that instant is photographed. At the same time, the position of the launcher (and hence of the mirror mounted on it) is obtained. Of course the position of the camera is also recorded by survey.

Thus, all three termini of the optical lever are known—chart, mirror, and camera. From the two resulting vectors the normal to the mirror may be deduced as a function of time for every microflash. If the mirror is mounted such that its normal is essentially parallel to the launcher axis, the effect of roll about the launcher axis may be ignored. Otherwise two mirrors are required.

The normal to the mirror is determined at the time the launcher is boresighted, yielding the relative orientation between launcher axis and mirror normal. Once the mirror normal

Figure 2. Cross-wind experimental layout of the test area.



is determined, it is easy to deduce the orientation of the launcher tube. This method gives angular orientation to plus or minus ½ milliradian and comparable accuracies for angular velocity and acceleration.

An allied technique is one employing the photography of fixed markers (lights) in the terrain by high-speed cameras mounted on the launcher. The principle is the same as that of the optical-lever technique. The camera-marker method is less accurate than the optical-lever technique and is employed when the frequencies of launcher vibration are relatively low.

TIME of emergence of the missile from the launcher tube, or of its release from guide rails, is generally obtained by photographic means. However, electric contact with muzzle fingers, carbon-rod break circuits, and magnetic pickups is also used. If microflash photography is employed, time of emergence can be measured to within better than plus or minus 1/2,000-second.

The position, velocity, and acceleration of the missile in flight are obtained in cross-wind launchings in the same manner as in launchings from stationary projectors. Photographic techniques are obviously most commonly utilized. These are well known and warrant no further comments here. If impacts on targets are involved, determination of impact time (say, by electrical means) and survey of impact position yield the desired trajectory data.

Accuracies of plus or minus 1.0 foot in position, 2 feet per second in velocity, and 30-60 feet per second per second in acceleration can be expected. Acceleration and thence velocity also can be obtained by means of accelerometers and associated telemetering equipment located within the missile.

If greater accuracy is desired, the missile in flight can be photographed by microflash illumination against Scotchlite backgrounds. Doppler-radar measurements are also in use for trajectory determination.

Impact position generally is determined by survey with survey accuracy. Knowledge of missile position at emergence and impact then yields range and deflection.

Time of impact is obtained either photographically or from timed targets and together with emergence time gives flight time. Possible accuracy here is plus or minus 0.001-second.

Spatial (angular) orientation of the missile in flight can be measured photographically as well as by internal instrumentation such as accelerometers and gyroscopes. If the orientation of the missile is desired in the neighborhood of emergence, an optical-lever technique with the mirror mounted on the missile may prove useful. Accuracy of data obtained by the various methods depends on the type of instrumentation used. In the case of the optical-lever technique, milliradian accuracy is possible.

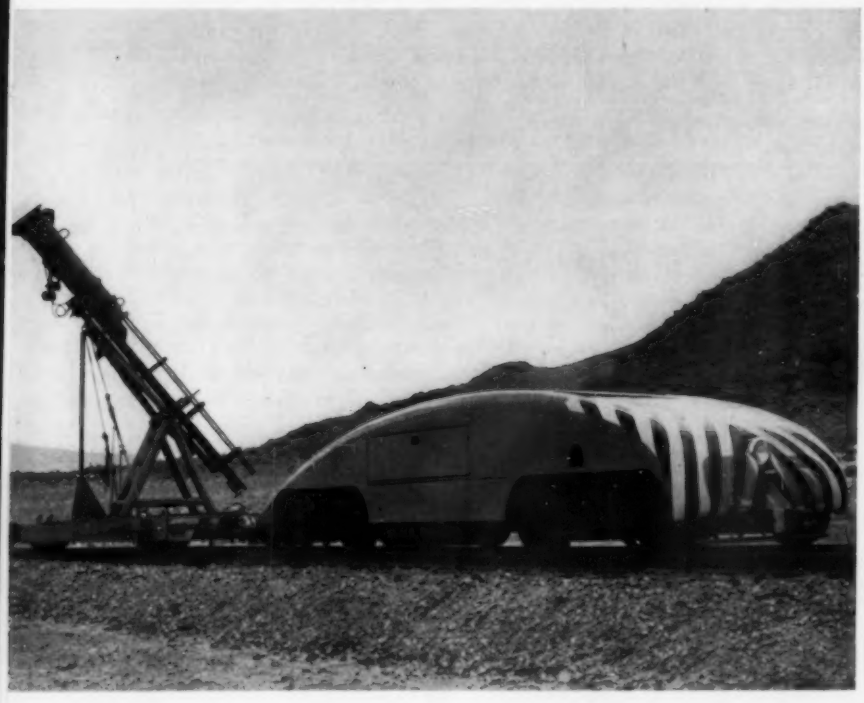
THE yawing motion of the missile is obtainable by instrumentation of the type employed in spatial orientation measurements; *i.e.*, photography as well as internal instrumentation. Pressure pickups have been used with good results to deduce a missile's yawing motion. Here again, accuracy is dependent on the sophistication of method and apparatus.

In conclusion, we might look at an actual experimental setup and see how the techniques just surveyed are used. Figure 2, shows a layout of the test area. As the carriage (1) moves downtrack, its speed is measured by means of magnetic pickups (2) and by a camera (3) in conjunction with a scale (4). The latter combination is also used to record its position at emergence. An optical-lever system from a nonrepetitive chart (5) to a mirror (6) to a camera (7) provides a means of determining barrel orientation. Time of projectile emergence is recorded by a camera (8) which photographs the emerging bullet against Scotchlite (9). A magnetic pickup (10) pulse is also telemetered to obtain emergence time.

ALONG the flight line (11), projectile position and orientation (in two planes) are recorded by cameras (12) photographing projectile silhouettes and images against Scotchlites (13) and in mirrors (14), respectively.

Microflash lamps (15) provide illumination for these measurements. Finally, range and flight time are determined by means of timed targets (16). All signals, including magnetic pickup pulses, microflash pulses, and target impact signals are recorded against a common time base.

Figure 3. Prime mover pulls launcher at speeds up to 50 knots (Navy photo).



Nike Quality Assurance

Bell Telephone Laboratories have developed a procedure which establishes quality standards for missile production, continuously evaluates the product, and helps prevent any significant departure from these standards

E. G. D. Paterson

THE term "quality assurance," as coined by the Bell Telephone Laboratories many years ago, has been used to describe a procedure by which the customer-user is continuingly assured that the product which he accepts is at a level of quality which he may reasonably expect.

While quality assurance is thus a function which is exercised primarily in behalf of the customer, the supplier himself benefits from its activities. In fact the supplier—particularly if he be also the manufacturer—plays a very active rôle in the quality assurance program.

While the supplier's initial reaction to quality assurance as it first applies to his product may in some cases be apprehension, this is normally followed quickly in characteristic sequence by tolerance, surprise, approval, and, finally, hearty coöperation and participation.

TO be effective, quality assurance must (1) Establish quality standards which, from the point of view of the customer, represent a product which is satisfactory, adequate, dependable, and economic; (2) Continuously evaluate product quality in terms of these standards; (3) Initiate measures to prevent any significant departures of product quality from these standards; and (4) Present continuing evidence as to actual product quality.

Successful attainment of these four goals involves six major activities, as follows: setting quality standards, preparing inspection practices, disposing of nonconforming material, handling engineering complaints, conducting quality surveys, and analyzing, evaluating, and reporting quality results.

Mr. Paterson is associated with the Bell Telephone Laboratories, Whippany, N. J. This article was an address given before a recent meeting of the Guided Missile and Rocket Division of the American Ordnance Association held at White Sands Proving Ground, N. Mex.

It is extremely important to bear in mind that while these activities are listed separately, they are so closely interrelated that the incorrect or inadequate administration of one of them jeopardizes the value of all the others and of the plan as a whole. Thus in Figure 1 they are shown grouped in a circle. As we consider each activity separately, we must keep in mind the qualifying effect of each of the others.

Since our over-all objective is to assure to the customer a product whose quality is at the level which he reasonably expects, we must define what is meant by quality and ascertain what quality level the customer expects. We must, in other words, establish suitable quality standards.

But, you may say, the specifications define what product quality is desired. Why not just make sure that all products meet the specifications? Certainly the specifications define the desired quality in a broad sense, or, at least, they ought to. But workmanship is not usually defined in the design specifications. Surely, workmanship is an important feature of quality.

Are we always satisfied to accept everything within the extreme tolerances permitted by the specification or don't we, in some cases at least, wish to insist on a better distribution than one which just gets by? Will one test ensure that we meet the intent of the requirements or must we make repeat tests and, if so, how many?

THESE and many other similar questions must be answered whether we are dealing with a product where substantial risks and defect tolerances are proper, or with one like the Nike antiaircraft guided missile where we are seeking the best quality practically feasible. Our answers involve the setting of quality standards, either specifically expressed or implied.

Inspection represents the traditional approach toward ascertaining and ensuring product quality. Whether the quality assurance organization performs the inspection function itself or whether it relies upon some other qualified agency to do this work, the inspection results which are used for quality assurance purposes must be pertinent, reliable, and adequate. The inspection procedures and acceptance criteria speci-

fied must, moreover, be compatible with the quality standards which have been established.

To be most effective, the inspection practices which specify these procedures and criteria should be tailor-made to suit the circumstances, stressing and implementing, as necessary, safeguards with respect to those features, such as safety or reliability or life, which may be of special importance.

The particular type of inspection procedure selected—attributes, variables, 100 per cent inspection, lot-sampling inspection, continuous-sampling inspection, etc.—depends upon many factors: the nature of the product itself, the number of units produced, how it was manufactured, whether process-control techniques have been applied, how, by whom, to what requirements and by what equipment it was inspected prior to its submission for acceptance, etc.

Failure of a product to meet a specified requirement constitutes a nonconformance. The departure from requirements may have a quality significance ranging from negligible to serious. The customer can always insist upon the repair of the nonconforming product, if the deviation is reparable, or he can reject it.

There are circumstances, however, wherein repair or rejection may not be to his best advantage. His need for the product may be so urgent, for example, as to outweigh the effect of the nonconformance on service.

EXPERIENCE has taught us that, regardless of the excellence of design and production capabilities, occasions will arise where we are obliged to consider carefully whether it may not be in our own interest to accept certain nonconforming products. Experience also has shown that, as a quality problem, such consideration and ultimate decision should be exercised as a quality assurance function.

When the customer receives a product which fails to meet specified requirements, fails to function as intended, or fails to provide reasonable life in service, he may enter an engineering complaint. The number and character of engineering complaints received provide a sort of negative index of quality—negative in the sense that complaints indicate possibly poorer quality than was intended and also in the sense that the absence of complaints does not necessarily indicate satisfactory quality.

Fig. 1. Activities of quality assurance.

Complaint handling forms a valuable source of information for quality assurance purposes in that complaints often disclose otherwise unsuspected shortcomings in design or manufacture. Moreover, the number and nature of the complaints provide a rough measure of the satisfactoriness of the standard quality level and of the mechanism used to ensure this level. The quality situation can still be healthy if the number and seriousness of complaints is kept within reasonable limits compatible with the nature of the product.

Investigation of a complaint involves the finding of the cause of the difficulty, recommending remedial action for the specific case at hand, recommending action to prevent recurrence when the economics of the circumstances warrant such preventive action, and assigning responsibility—the latter forming the basis upon which the supplier may make adjustment if such is involved.

A schematic of this complaint-handling activity based upon the procedure which we use in the Bell System, is shown in Figure 2. Note especially how the other quality assurance activities are brought into play.

THE quality survey has been characterized as the most important single cog in the quality assurance machinery. It comprises an over-all review of all factors relating to the quality of a particular product, to the end of determining what the quality should be, what it is, and what must be done, if anything, to get the quality where it should be and to keep it there.

The survey is conducted by a survey committee usually consisting of three people—one member from the quality assurance organization who acts as chairman (he is an engineer who is a quality specialist on the particular product under survey), one member from the inspection agency which provides the quality assurance department with inspection information covering the product, and one member who represents the manufacturer or supplier.

Survey subjects are selected for their timeliness from a quality standpoint as evidenced by the complaint history, the inspection results, and the number and nature of nonconformances. The importance of the product in terms of the nature of the service it is designed to provide, the quantity of output, and its monetary value are, of course, primary factors in the selection.

ALL major items of product are covered, and repeat surveys are made on a cyclical basis at time intervals consonant with the importance of the product and the likelihood of its becoming subject to quality-degrading influences.

In analyzing, evaluating, and reporting quality results, all the quality information furnished by all the other activities is gathered together, the inspection results analyzed, and the reports on product quality prepared. Important components or products are usually quality-rated individually. Important types of associated groups of apparatus or components may be combined in over-all rates. Finally, the composite quality of all products is rated on a quality index basis.

Included in the quality report are not only the individually important and over-all rates, but also significant comments on quality arising from the other quality assurance activities—notably engineering complaints and quality surveys.

The organizational setup of the quality assurance department is very important. Let us keep in mind that production people are faced with the obligation to maintain low costs and to meet close schedules. Similarly, design engineers, especially in these busy times, are under heavy pressure to get designs into production with a minimum of time and field trial.

The quality assurance organization, on the other hand, has no responsibility

for design or production, for costs or schedules. Its function is to evaluate product quality and to initiate action toward the removal of any quality shortcomings, actual or potential. It is thus in a particularly favorable position to act judicially.

To do so, it must be fully independent of, and have authority fully equal to, those with whom it does business. Should its status permit overruling except by authority higher than design, production, and quality assurance, and except on the basis of factual merits, the benefits to be gained from an independent, unprejudiced, critical judgment are lost.

The quality assurance activities are, as will have been noted, largely engineering—engineering with a particular slant, perhaps, and with a better than usual appreciation of the laws of probability, statistical distribution, and quality control—but nevertheless engineering. Hence about eighty-five of the total of slightly over one hundred people in the quality assurance department in the Bell Laboratories are engineers and their technically trained assistants.

A dozen or so are women college graduates with mathematical and statistical training, and about a half dozen are clerical people. The close coördination among the various activities, which is vital to the success of the whole quality assurance program, is possible only if we provide for a high degree of communication. Our organizational setup ensures this.

ABOUT half of the entire personnel are classed as quality specialists. Each one of these specialists is an engineer highly trained with respect to his specialty—a particular type of telephone product or a group of closely similar products. He is responsible for all phases of quality assurance associated with his specialty.

He handles all the engineering complaints, passes upon all nonconformance cases, determines the inspection practices to be followed (with any necessary assistance provided, as will be explained later), sets the quality standards, supervises the analysis of inspection results, and conducts all quality surveys on his specialty. Thus each specialist is essentially Mr. Quality Assurance in so far as his particular product is concerned.

In our judgment, this organizational plan of having a single individual responsible for all phases of quality assurance with respect to each major specialty is the most important single factor in the success of the quality assurance plan.

A SECOND, and much smaller group in the department comes under the heading "quality methods development." These are people highly trained in the theories of statistics and quality control. They are responsible for the development of new theories and techniques of sampling, quality rating, and quality control.

They represent in a sense the development and research group in the department. In this group have originated the basic concepts of the control chart, defect tolerances, consumer's and producer's risks, and scientific sampling inspection plans. These people are frequently consulted by the quality specialists for assistance and advice concerning the best methods of sampling and quality rating.

They ensure that the inspection practices and quality rating procedures are uniform and consistent from a statistical point of view, prepare certain of the more general types of inspection practices, consolidate the several quality rates associated with the various types of products, and plan and edit the overall quality report which has been mentioned.

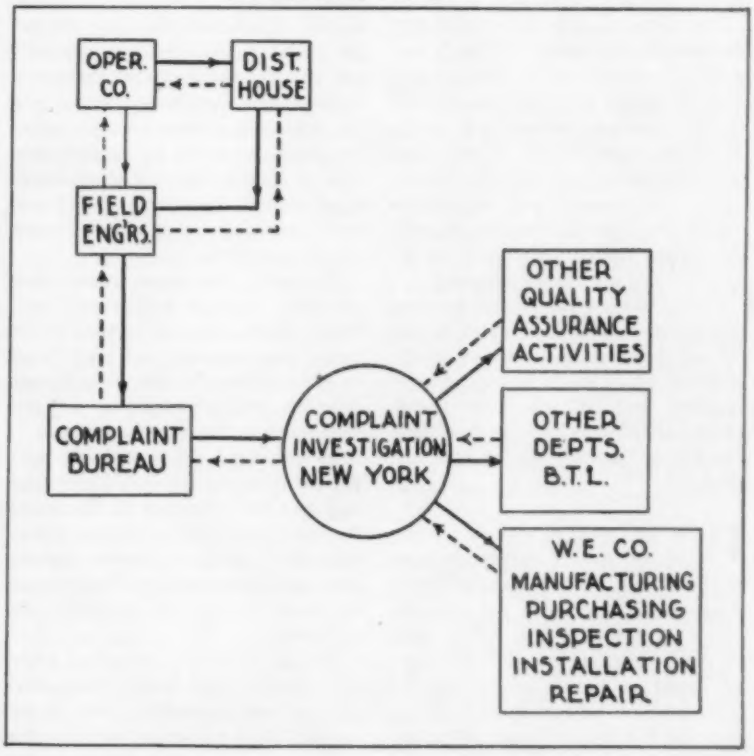
UNDER the terms of the Nike quality assurance contract, which became effective in July 1953, we undertook to do two things:

1. Develop and get into operation a quality assurance plan for the Nike I round, patterned after the plan which had been in use so long and so effectively in the Bell System.

2. Train a small group of Ordnance engineering personnel in quality assurance techniques so that this group could form the nucleus of a larger group which could expect to carry on the current program and to expand the application of quality assurance procedures to other types of missiles.

Our first task in carrying out the contract was to set up an organization.

Fig. 2. Engineering complaint flow chart.



Under our commitment we were expected to assign the equivalent of 8½ full-time engineers and the necessary supervision. The Bell Laboratories' quality assurance engineers have, of course, been selected for their specialized knowledge of electronics, mechanics, etc., as well as their competence in quality assurance techniques.

Having in mind that the guided-missile field was new to our people, we tried to select a group of engineers who would represent the "quality specialists" mentioned earlier. We selected also a few people who would serve as the statistical experts and advisers.

SIMILARLY, we tried to assign our "Ordnance opposite numbers" on the basis of best using their prior engineering training and experience. Some of our people have full-time assignments on the Nike job—some part-time.

The better part of the first year on the project was spent in acquainting ourselves in detail with the design and function of the over-all round and its components, with the sources of supply, with the manufacturing locations and procedures, and with the basic planning of the most effective over-all quality assurance approach.

The Nike missile is a complex electromechanical device and, while our quality assurance engineers have had wide experience with such devices, the missile introduced to them new physical interrelationships and, in particular, new aërodynamic and ambient environments. It is axiomatic with us that our quality specialists must be familiar with the design, function, manufacture, inspection, and use of their specialties.

During this educational and planning period, our engineers, of course, looked for any shortcomings in design or construction which might be more readily apparent and, if any were found, recommended steps for correcting them —a sort of "putting out the fires" approach.

IN the late spring of 1954 we inaugurated the quality survey program on the project. We tried to schedule the program so as to cover the most important components first, but to cover all the components as well as the over-all round as quickly as possible. To date, we have held 37 quality surveys resulting in a total of some 116 recommendations for action by the contractor's development, manufacturing, and inspection organizations, the Ordnance Corps, and by our own quality assurance group.

The quality assurance committee membership on each of these surveys included both a Laboratories' quality assurance specialist and one of the Ordnance engineers assigned to the project for training. The survey program has proved to be and will, we believe, continue to be a fruitful source of quality improvement.

During the past year or so we have been gradually shifting our emphasis toward the inspection agency procedure phase of the job, that is, toward the formulation of inspection plans. These, as well as other procedural documents relating to quality surveys, rating, etc., are being incorporated into what we call "quality assurance procedures," or "QAP's" for short. Broadly speaking, this work involves reaching and implementing three basic decisions; *i.e.*, what to inspect, what to inspect for, and how many to inspect.

IN arriving at these decisions we must bear in mind (a) the high reliability desired of the round, (b) the scarcity of personnel possessing the special skills required for the inspection job, and (c) the fact that the procedures should represent a general pattern applicable to other guided missiles. Obviously, it would be impracticable, even if it were considered otherwise reasonable, to inspect all rounds and their constituent parts for all measurable requirements.

Obviously, also, certain quality characteristics, such as workmanship and finish, which cannot be verified by objective measurements and must hence be evaluated on the basis of judgment, should be subject to some scrutiny and verification by the inspection agency.

In any event, the procedures incorporated in the QAP's should recognize, and take full advantage of, the manufacturer's inspections and inspection results which, under the quality assurance plan, are continuingly verified by quality survey as to their adequacy and reliability.

By and large, the inspection procedure QAP's cover major components, that is, coded assemblies. We are preparing QAP's on one or two subassembly items where circumstances indicate the advisability of so doing.

Underlying all these QAP's will be arrangements whereby maximum use will be made of the information resulting from the manufacturer's inspections and quality-control procedures.

AN outstanding example of potential savings is represented in the QAP covering the ballistic testing of the booster. As compared with the inspection procedures in effect at the time of the initiation of the quality assurance contract, the current procedures under the QAP's should result in savings of over a million dollars a year—over $750,000 has already been saved in the past nine months during which the QAP's have been on trial.

The savings of course, arise from the destruction of a smaller number of expensive components. The smaller test sample results from a thorough study of the sources and extent of product variability and the utilization of this information together with running statistical control criteria to permit a tailor-made inspection procedure which justifies a minimum sample size.

While formal procedures for analyzing and reporting quality results have not yet been set up, we have, of course, been checking the inspection and field performance data.

How does quality assurance relate to reliability? There are many different definitions and concepts of what is meant by "reliability," but if we are willing to agree that "the ability of the product to fulfill its intended function" does not come far from a good qualitative description of reliability, then there is little, if any, incompatibility between this and the objectives of a quality assurance program in which economic factors are considered.

This brief review would be incomplete if I did not mention the excellent coöperation which we have had from the suppliers and manufacturers associated with the Nike I round.

While the work on this project is not completed, there is sufficient evidence to show that the quality assurance plan described can be applied effectively to guided missiles with results which are of substantial benefit to the designer and the manufacturer, as well as to the customer toward whose interests the plan is primarily directed.

Metals in the Atomic Age

The use of powder metallurgy in fabricating beryllium, zirconium, uranium, and thorium has helped solve problems of heat transfer, corrosion, and radiation damage in the engineering of elements for use in nuclear reactors

Henry H. Hausner

POWDER metallurgy is an extremely interesting and important method for the fabrication of nuclear fuel and other components for nuclear reactors. Among the many engineering difficulties which are encountered in nuclear reactor design, such as heat transfer, corrosion, and others, there is an entirely new problem—the so-called problem of "radiation damage."

Let us consider briefly the effects of radiation on materials. During the last few years we have learned that materials change under irradiation—they may change their physical properties, and they may even change their dimensions and densities. These changes depend on the type and level of the radiation, on the type of the material under irradiation, and also on the state of the respective material—whether it is annealed or hard, whether it is cold-worked or not, and whether it is irradiated at low or high temperature.

IRRADIATION causes some hardening in carbon steel, stainless steel, nickel, and zirconium, for example—the degree of hardness depending on the radiation level, on the material itself (there is very little effect on zirconium), and on whether the material is annealed or hardened. All four metals increase in hardness when annealed, but change much less in the hardened state.

What actually is the difference between materials annealed or unannealed in terms of their structure? In an annealed material the atoms are mostly located in place in their crystal lattice—*i.e.*, they are ordered—whereas in the unannealed state many of the crystal lattices show defects such as dislocations of the atoms or vacancies in spots where atoms are supposed to be. In other words, the atoms in the crystal lattices are disordered.

Mr. Hausner is general manager of the nuclear engineering division of the Penn-Texas Corporation. This article was originally presented as an address before a meeting of the A.O.A. Powder Metallurgy Committee in Sperryville, Va.

As you all know very well, there are certain alloys, so-called order-disorder alloys, which can be fabricated in whatever crystal lattice state we want them. The copper-gold alloy is one of these order-disorder alloys. Several years ago Billington and Siegel of Oak Ridge National Laboratory investigated the effects of irradiation on the electrical resistivity of this copper-gold alloy in the ordered as well as the disordered state. The ordered alloy increases in electrical resistivity considerably under irradiation, whereas the disordered alloys do not change at all.

Any fine metal powder particle is, in my opinion, basically different from the same metal in large dimensions. The difference is twofold: First, the powder particles are characterized by the large ratio of surface area to volume, and, secondly, practically all the surface crystal lattices in metal powder particles are in a defect state and disordered. When we compact these powder particles and sinter them at not too high a temperature, or hot compact them, the sintered compact is still characterized by uniform and randomly dispersed defect or disordered lattices of the powder particles.

POWDER metallurgists never had considered this fact, and especially had never thought that these randomly dispersed, disordered lattices could be of any importance. However, from what I have just said about effects of irradiation on ordered and disordered lattices in metals, it should be evident that powder metallurgically prepared metals offer some advantages with respect to the phenomenon which we call "radiation damage." However, it should not be concluded that all metal used in a nuclear reactor should be made by powder metallurgy.

The four "new" metals which are of greatest interest for nuclear reactors—beryllium, zirconium, uranium, and thorium—can be fabricated by powder metallurgy. Beryllium, the ideal material for moderators in nuclear reactors, is advantageously produced by powder metallurgy. Unfortunately, beryllium is so expensive that economic considerations do not permit a wide use of this metal.

However, some observers feel that if

the U. S. Government would try to encourage industry and try to help overcome the difficulties in setting up an economic production plant by the guarantee of enough orders within a limited period of time, the cost for beryllium metal would decrease considerably.

THE price for beryllium at present is $150 a pound and some manufacturers can envisualize that this price may come down to approximately $50 if the Government would show more interest as a buyer.

Zirconium is another material for nuclear reactors, especially well suited for the protection of fuel elements from corrosion, as an alloying element, and also as a material of construction. Zirconium is an ideal material for powder metallurgical purposes. It sinters at a fairly low temperature to the theoretical density of the material; very few other metals behave so well during sintering.

Uranium and thorium are most important metals in nuclear reactors—they are the "fuel" in which the nuclear reaction takes place. It took several years until we had developed and learned to understand the powder metallurgy of uranium, for this metal offers many difficulties. There is only one metal which is harder to handle than uranium, and that is plutonium. Thorium is excellently suited for powder metallurgical production.

Beryllium powder is known as one of the most toxic materials. A penetration of beryllium powder particles into the human body may cause death. Zirconium, even in the form of a fine powder, is not toxic; however, when the powder particles are too fine, in the range of approximately one micron or less (we usually do not use powder particles of this small diameter in powder metallurgy, but they may be included in coarser powders), they are under certain circumstances highly pyrophoric and may ignite.

Uranium in powder form is both toxic and pyrophoric to a high degree. Thorium powders are also toxic and pyrophoric, but to a lesser degree.

The dangers involved in handling these powders made it necessary to develop new techniques of fabrication, and they are handled in so-called "dry boxes." When beryllium powders are handled the operator merely must be kept from coming in contact with the toxic powder, and the dry box may be filled with air. Uranium and thorium powder particles, however, have to be handled in vacuum or an inert atmosphere in order to prevent them from becoming ignited.

All these factors must be carefully considered by any one who wants to go into the fabrication of these nuclear reactor metals by powder metallurgy.

Zirconium and thorium powders can be compacted to a very high density, whereas beryllium and uranium powders do not compact so well. Beryllium is a nonductile metal, and the particles do not deform during compaction. Uranium powders are usually so extremely fine that they cannot be compacted to a very high density.

URANIUM powder compacts at normal pressures to a low density, and even with the application of fairly high pressures the density does not increase too much. Uranium powders subsequent to compaction at room temperature do not sinter well.

What we want for nuclear reactor purposes, however, is uranium of perfect density and with no porosity and characterized by a uniformly fine grain structure. Sintering, even close to the melting point, results in a low-density compact only, containing extremely large crystal grains. General powder metallurgy experience has taught us that repressing or coining usually considerably improves the density and creates the crystal nuclei for a fine-grained structure.

THIS general experience, however, does not apply to uranium. Repressing sintered uranium powder compacts, even at almost unreasonably high pressures (175 tsi), improved the density but little and resulted in a structure which looked like fine grains. These fine grains, however, proved to be just subgrains within the larger grains and behaved under test like the large grains from which they were formed.

There is only one method for obtaining a perfect powder metallurgical uranium, and this is the hot-pressing method. Hot compaction at approximately 10 tsi and 600 degrees centigrade in vacuum for just a few minutes results in a perfectly dense, fine-grained uranium, usable in nuclear reactors. This kind of hot pressing is also economically applicable to commercial production.

Powder metallurgy is especially valuable for the solid-state production of certain alloys.

Formation by melting of alloys consisting of very heavy components (such as uranium) and very light ones frequently results in segregation of the components in the liquid state and requires usually one or more remelting steps. The powder-metallurgy fabrication of alloys in which the components are mixed in powdered form does not result in segregation, and on account of the solid-state reaction below the melting temperature of the components results further in a low pickup of gaseous impurities.

It seems that fuel elements for some types of nuclear reactors can best be made by a combination of metals and nonmetals. "Cermets," consisting of stainless steel and uranium dioxide, offer many advantages for nuclear fuel, and these can be fabricated only by powder metallurgy.

Effects of irradiation on electrical resistivity of copper-gold alloy.

Resistivity* of Cu_3Au Samples Before and After Irradiation

Neutron flux†	Ordered samples		Disordered samples	
	Before	After	Before	After
0.4	4.60	5.71	11.20	11.25
0.6	4.60	6.25	11.20	11.25
1.0	4.60	7.54	11.20	11.17
1.5	4.60	8.36	11.20	11.21
3.3	4.60	10.10	11.20	11.30

* Unit of resistivity: 10^{-6} ohm-cm.

† Unit of flux: 10^{19} neutrons per sq. cm. The samples were exposed at various positions in the pile at 40° C. and the integrated flux per sq. cm. of neutrons with energy above 50,000 eV was as shown.

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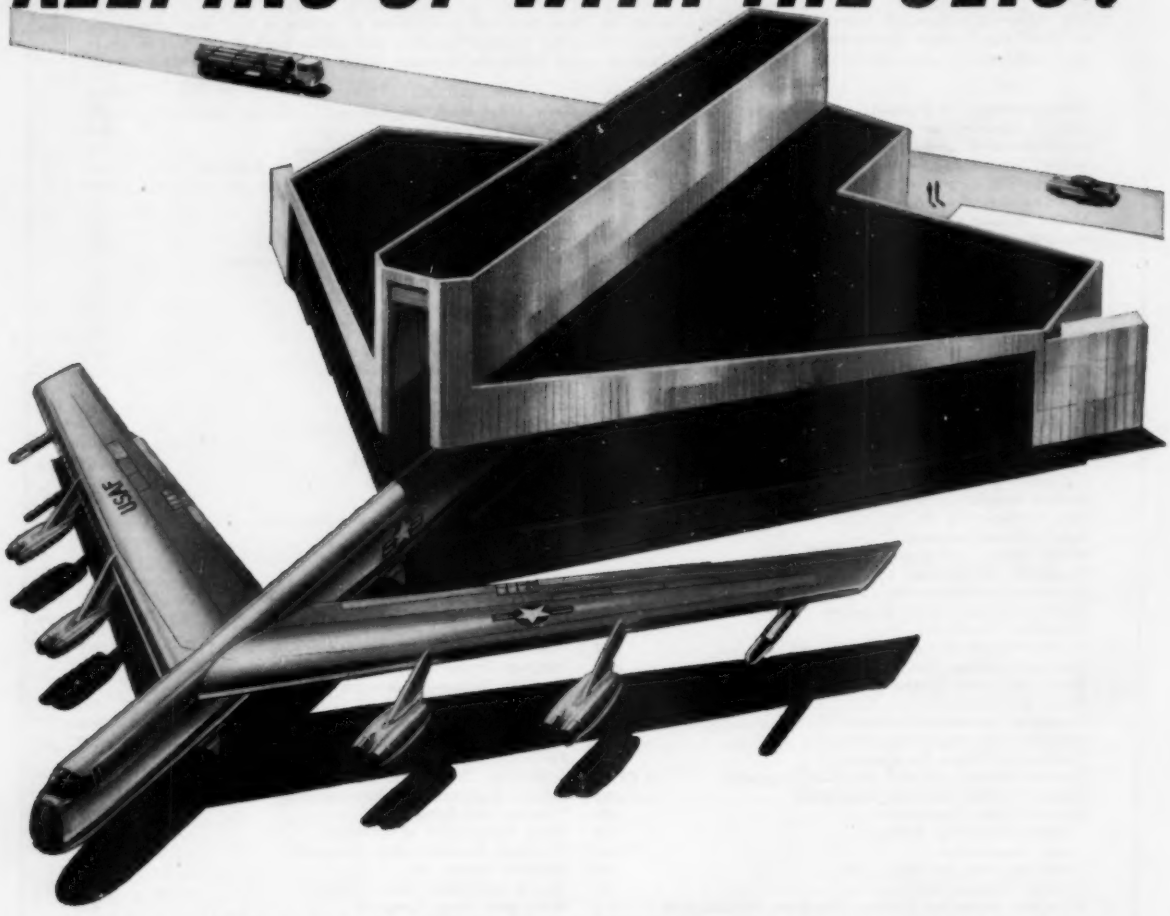

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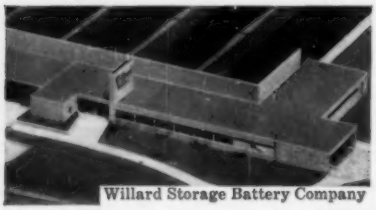

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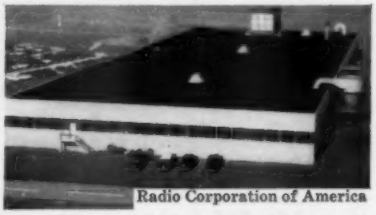

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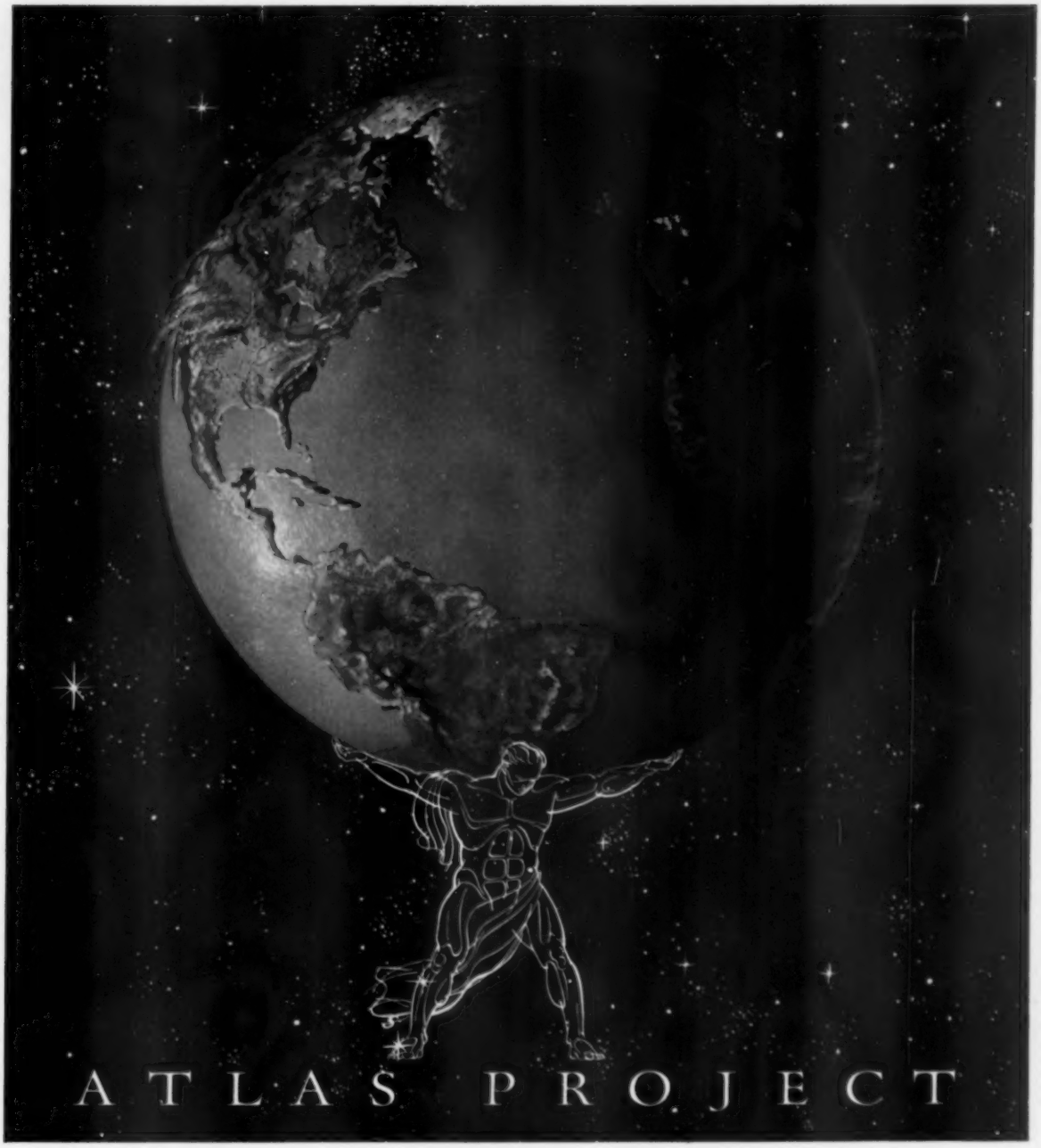

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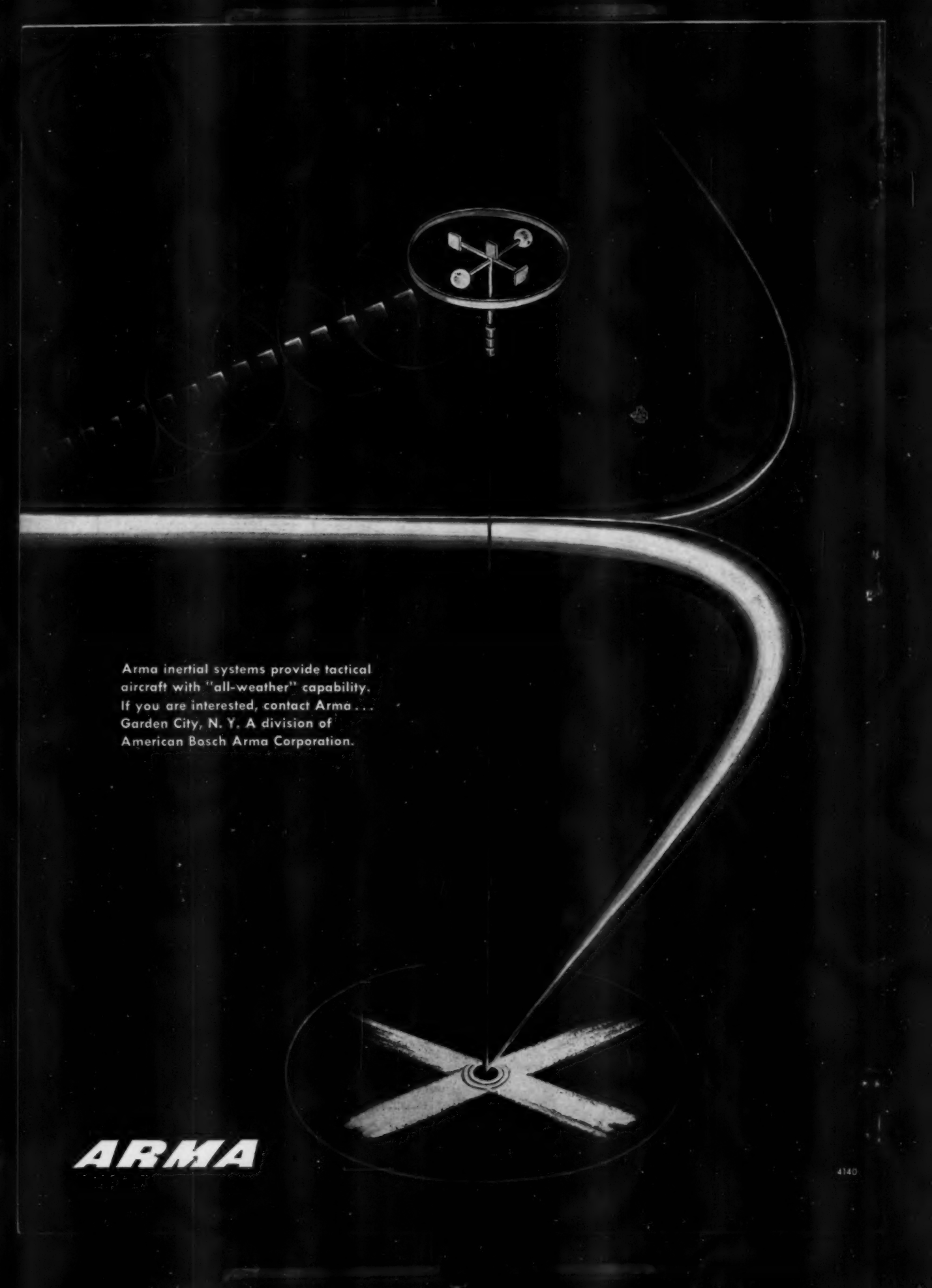
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